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A PUBLICATION OF THE MIT LABORATORY OF ARCHITECTURE AND PLANNING

Massachusetts Institute of Technology

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PREDICTING THE LOCAL IMPACTS OF ENERGY DEVELOPMENT:
A CRITICAL GUIDE TO FORECASTING METHODS AND MODELS

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May 1977

PREPARED FOR THE UNITED STATES
ENERGY RESEARCH AND DEVELOPMENT ADMINISTRATION

Under Contract No. E(49-18)-2295

U.S. DEPARTMENT OF COMMERCE NOAA
COASTAL SERVICES CENTER
2234 SOUTH HOBSON AVENUE
CHARLESTON, SC 29405-2413

Massachusetts Institute of Technology
HD9502.U52 S859 1977
4621926
MAR 25 1997

Funds for this project provided by
the Division of Biomedical and Environmental Research of
the United States Energy Research and Development Administration

Project Title:

Environmental and Community
Service Impacts of
Energy Facilities

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Abstract

Models forecasting second-order impacts from energy development vary in their methodology, output, assumptions, and quality. As a rough dichotomy, they either simulate community development over time or combine various submodels providing community "snapshots" at selected points in time. Using one or more methods -- input/output models, gravity models, econometric models, cohort-survival models, or coefficient models -- they estimate energy-development-stimulated employment, population, public and private service needs, and government revenues and expenditures at some future time (ranging from annual to "average year" predictions) and for different governmental jurisdictions (municipal, county, state, etc.). Underlying assumptions often conflict, reflecting their different sources -- historical data, comparative data, surveys, and judgments about future conditions. Model quality, measured by special features, tests, exportability and usefulness to policy-makers, reveals careful and thorough work in some cases and hurried operations with insufficient in-depth analysis in others.

Acknowledgements

Various researchers and staff members helped us acquire these studies; many constructively criticized the preliminary hypotheses and evaluation criteria. In particular, Edward Helminski was generous of his time in locating references and Donald Patterson functioned as a sounding board and contributed essential insights into the political and financial climate surrounding projection studies. Three Energy Impact Project staff members shared administrative tasks: Catherine Lu and Lynne Monaco located forecasting models prepared in particular states; Robert Foster also discussed conceptual problems at length. Several typists willingly and skillfully produced the several drafts of this paper. Despite all this help, remaining errors are our own.

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PART I: INTRODUCTION

Objectives

In the "boomtowns" of American legend and history, people sought to "strike it rich" but gave little thought to the impacts of development on the community at large. Today, however, many westerners oppose energy development lest it reduce the quality of local public services and destroy their current lifestyles. To learn how this energy development will affect their communities -- immediately and in the long run -- many planners and public officials have turned to mathematical projections of the "second-order impacts" of development for a look at the future that will follow development. (First-order impacts, such as population increase, don't concern people as much as the resulting second-order impacts, like over-crowded schools caused by newly arrived families.) In the following pages we review the methods which have been used to predict the second-order impacts of energy development.*

We begin with a general introduction to predictive models and their uses and then discuss the most common techniques used by the studies reviewed. The last section -- not intended to be read straight through -- describes critically the salient features of each forecasting model.

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*"Prediction," "forecast," and "projection" all describe views of the future but connote different degrees of confidence that both the initial conditions and the outcomes will take place. We use the terms interchangeably since we focus on the methods used in determining future conditions rather than on the reality or expectation of different models' initial conditions in different applications.

Coverage

Although we intend to cover all reputable studies on this topic, this edition excludes some studies recently or not yet obtained. Section III lists these models for the reader's convenience. Where several publications report results from the same model, we have reviewed only the most thorough publications. Some models are not emphasized since Stenejhem's study [46], which we recommend, presents an excellent evaluation of them.

Introduction to Modeling

Vocabulary

The technical vocabulary of mathematical models is not forbidding, but since some terms are often used carelessly and some have specialized meanings, this section will review the language model users are likely to encounter.

It is useful to consider a model as a simplified picture of the real world (Figure 1). In the real world, a variety of phenomena can be observed of which only a few can be measured or counted. Most model designers simplify the real world (for which decisions must be made) into a few measures which capture the important characteristics of the phenomenon under study as the value of certain numbers. For example, the phenomenon of education might be simplified into "number of students" and "number of full-time-equivalent teachers." Each of these becomes a variable in the model; the model is used to generate values for some of these variables. If the model is a good one, the values it generates are close to what the real world would show.

The model generates values for its variables by mathematical rules (functions, or equations) whose form describes the "kind" of relationships believed to obtain between the variables and whose coefficients and constants -- parameters -- describe the "amount" of this relationship assumed.

For example, if we think that the number of teachers in a school system is a constant multiple of the number of students, we might construct the function

$$T = A_{tp}P \qquad (1)$$

where

- T is the number of teachers
- A_{tp} is the parameter of the relationship
- P is the number of pupils

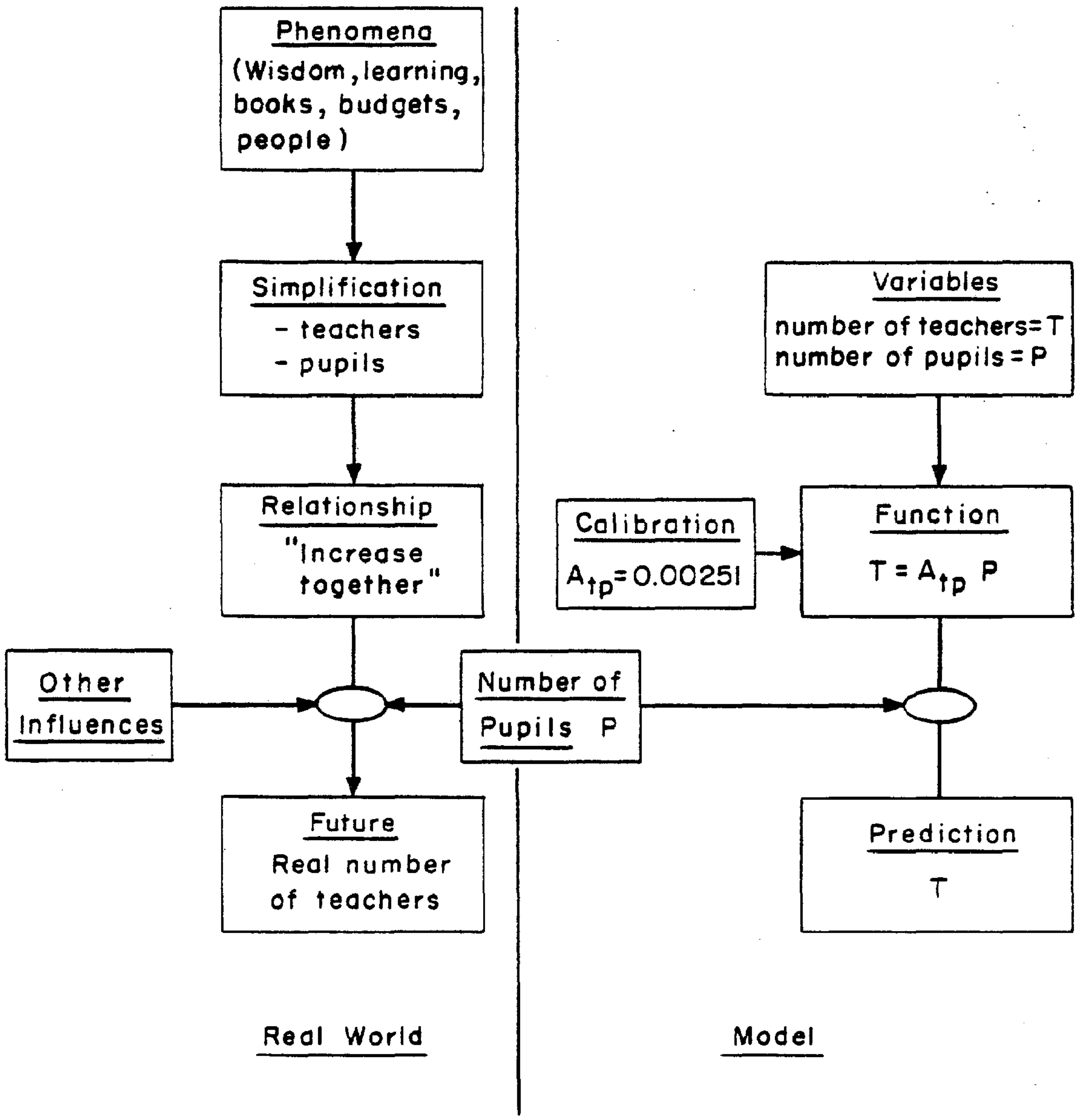


Figure 1

Model - World Correspondence

To use this relationship, which is constructed on the basis of some theoretical or empirical knowledge that enables us to select it from among other candidates like

$$T = A_1 + P \tag{2}$$

$$T = P/A_2 \tag{3}$$

$$T = (P-325)^{A_3}, \tag{4}$$

we have to calibrate the model, choosing values for the parameters. This is usually done by running the model "backwards" with all variable values supplied (from existing real-world situations that are hoped to be similar to the new situation the model is supposed to predict) and observing the values of the parameters that result. For example, if we know of several cases like the following:

Case	T	P	Implied A_{tp}
I	42	1603	.0262
II	632	25,200	.0251
III	10	430	.0233
Mean	228	9,077	.0249

we might set A_{tp} equal to 0.0249.

To use the model, we supply values for exogenous variables (the ones the model does not generate); in our little example, we would supply a student population, say 100. The model then generates a value for T as $(2.49 \times 10^{-2})\ 100 = 2.49$. The model's prediction of teacher full-time equivalents is 2.49, which is precise to three significant figures. Whether it is accurate or not depends of course on whether (1) is correct and whether we calibrated it correctly. It might also depend on less analytical considerations; if we know that teachers will be hired in full-time positions only, the number in real life can only be 2 or 3.

Another way we might err is in the selection of our exogenous variable's value; this value, together with the form of the functions we select, is one of the assumptions used in constructing and using the model. Assumptions may be unsupported (judgmental) or may result from thorough theoretical and empirical research. Often, they are tested. Two kinds of tests can be used. The first, sensitivity testing, attempts to determine whether the model's predictions change as the assumptions change. As a trivial example, we might run the model with the parameter B taking on different values; since B does not appear in (1), the prediction of T is obviously insensitive to changes in B. (It is obviously quite sensitive to changes in the assumed value of P!) If we were nervous about the estimate of B that we wanted to use, such a test would be reassuring that a bad guess for B wouldn't damage our predictions.

The second kind of test includes all those experiments, like running the model from known data in a situation for which the outcomes are known, which confirm or challenge its overall credibility. If we tested the model on pupil enrollment in West Gulch, 1972, and it predicted 2.42 teachers while West Gulch actually had sixteen, with no plans to fire any, we would doubt the validity of the model.

One way models reflect changes in the economy is to trace the movement of dollars through their various rounds of spending. Input/output models divide a region's economy into sectors according to their product and they show how one dollar put into production in one sector will affect the other parts of the region's economy. Assume a ton of coal output costs the mining sector $4 for each hour of labor it uses. Part of each dollar spent for the labor input will find its way to the manufacturing sector in exchange for clothes; the manufacturing sector in turn will spend part of that dollar in the industrial sector for plastic to make buttons, and so on. Each dollar spent by the mining sector will make its rounds through a variety of sectors, its final impact being some multiple -- the interdependence coefficient -- of its original size. Multiplying an assumed business volume in the mining sector by that sector's interdependence coefficient will tell us the economy's gross business volume resulting from the mining sector's activities.

Another way models predict future conditions is through multipliers, simple ratios which predict one variable in terms of another. Standards often relate costs or jobs to population through per capita ratios, such as "county expenditures per person" or "doctors per 1000 people," but they may also be used to represent simultaneous changes in variables (workers-per-family, persons-per-family, or population-per-employee). Many models use adequacy standards to represent the level of public and private services and facilities "needed" by a population for suitable living conditions.

Another type of standard, also called a multiplier, involves a more complex theoretical base. To develop employment multipliers, a model must divide the economy into two sectors: the export sector includes all activities producing goods and services sold to buyers outside the region, while all remaining activities are a part of the local sector which produces goods and services consumed within the region. According to export-base theory, employment (including workers involved in local-sector activities), is a linear function of export employment (workers involved in export sector activities), the function being represented by an employment multiplier, the ratio of total to export employment. Assume a region has an employment multiplier of 2.5. If export sector employment is expected to increase by 1000 because of a new electric generating plant, then total employment is predicted to increase by 2500 (1000 x 2.5 = 2500).

Types of Models

Prediction models, which are developed and applied at a real cost in money and effort, are presumably worth using because they will improve the decisions planners and government face under conditions of uncertainty. A good model will fit the decision at hand -- whether by good fortune, if it is adopted from a previous use, or by design -- in three ways:

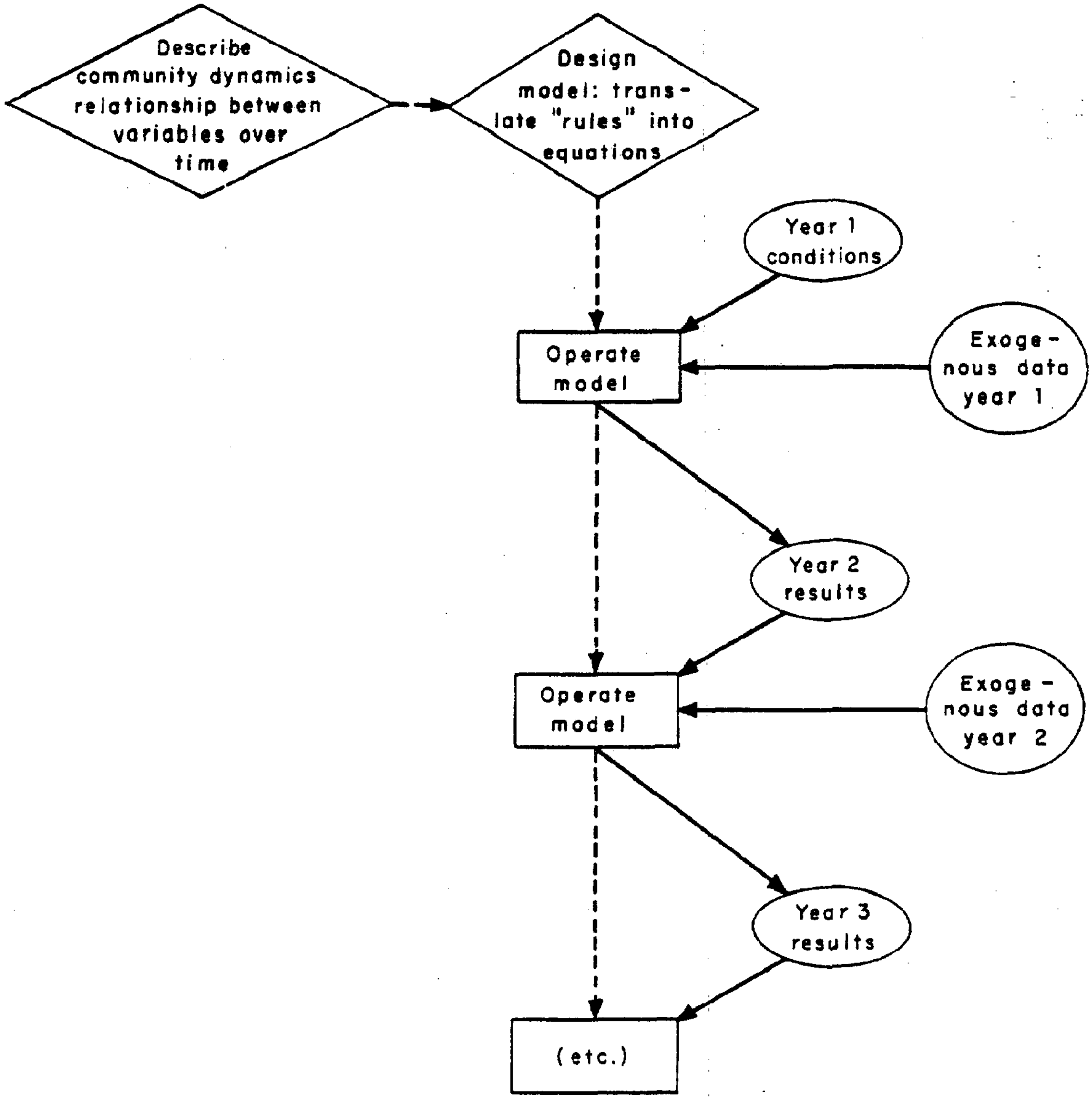
(1) The variables predicted are those related to the problem at hand; if the decision a town faces involves planning school construction, the model chosen or designed should provide complete predictions of education-related variables, might usefully predict government revenues and total non-education obligations, but probably should not waste computer time and an analyst's labor on crime and water-resource projections.

(2) The predictions will be made for a useful time or time series; some models generate results for a "typical year twenty years hence" while some generate annual values for twenty successive years.

(3) The model should match the decision-making jurisdiction usefully. A town planning its school budget will probably obtain little help from a model which generates school enrollments for a six-county region.

In addition to choosing a model which fits its application in subject, time, and scope, the user has to choose between two principal classes of models, <u>simulations</u> and <u>coefficient models</u>. While models in both classes simulate the real world and use coefficients in their equations, a simulation model (Figure 2) predicts community growth and change from present conditions while coefficients model (Figure 3) generates values for the dependent variables from selected assumptions about future conditions. A simulation model combines equations which define the relationships among the relevant variables and which transform conditions in one year into the conditions in the next year. Operating the model with the first year data yields the second year results and the second year results become the data for predicting conditions in the third year.* Thus the model generates successive sets of values for variables, one set for each future year, with each set depending on the values from the previous year. The important characteristic is the model's ability to portray changing conditions, year after year, without any adjustment of the equations themselves.

*Some models proceed in steps of different sizes -- months, seasons, or decades have been used -- but years are typical.



Key:

Model design decisions
Model operation
Model result (output) or data (input)
Sequence of model use
Flow of data or result

Figure 2
Simulation model

Simulation models apply a set of relationships between (usually) a single year's variable values and their values for the next year. Once the model is designed, it is applied repeatedly, simulating the changes expected in the real world, sometimes with annual data not generated by the model.

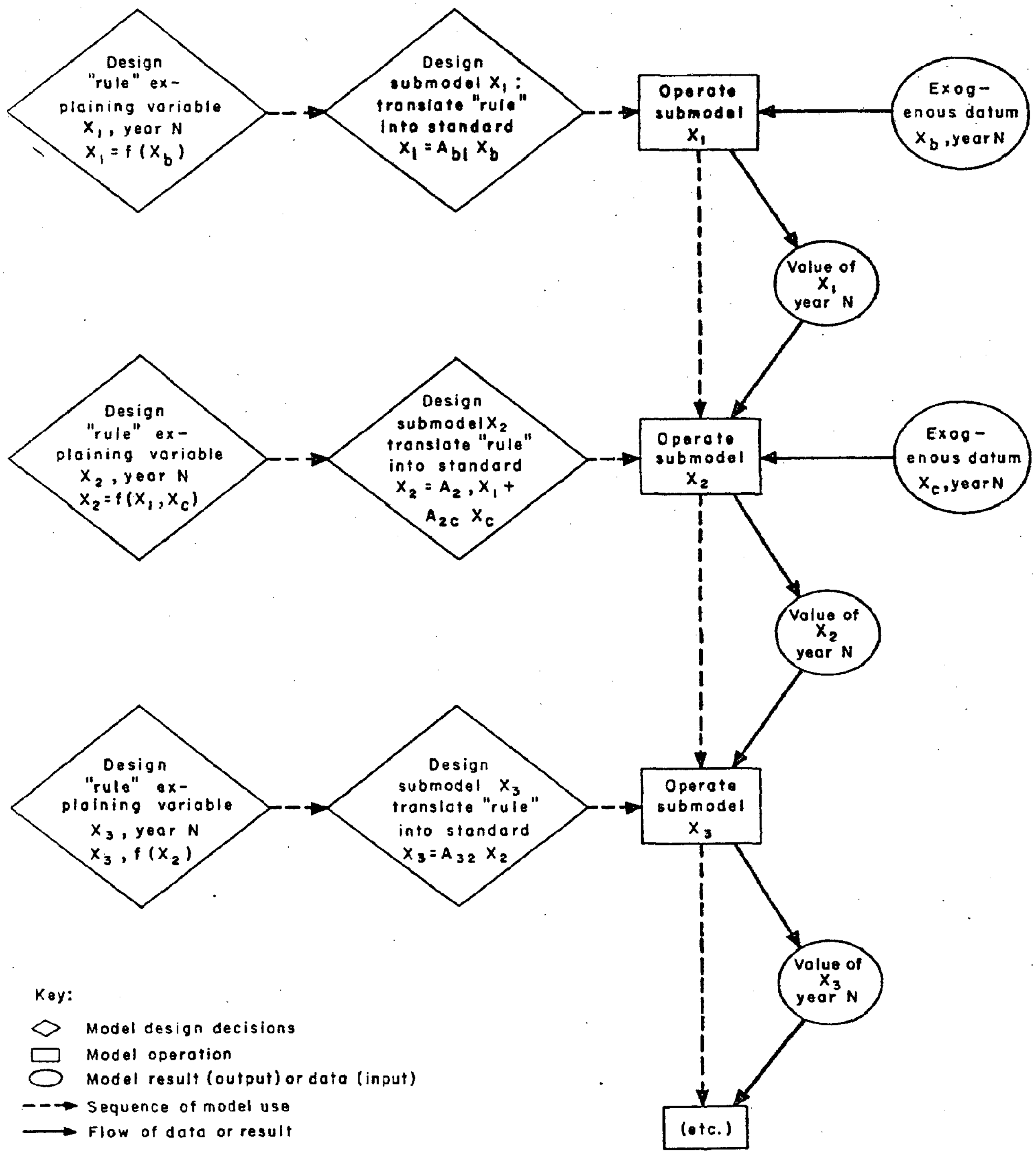


Figure 3
"Coefficient" model
"Coefficient" models follow a sequence of logical dependence but not a temporal or causal sequence. They generate values of different variables in a single year, each depending on one or more of the values computed previously.

The coefficient model does not directly simulate changes over time but instead provides "snapshots" of conditions in selected years. An equation predicts the value of a dependent variable at one point in time given a value of the initial, independent variable. Another equation relates this result to a third variable and predicts its value in turn, and so on. Instead of having one model which predicts values for all variables over time we have a collection of "submodels," each of which predicts a value for one variable at one point in time. These submodels might have to be redefined to make predictions for a different year.

The distinction can be caricatured by calling a simulation a "working model" of the real world while a coefficient model is a description of the ways various aspects of the world "tend to change together."

Most models are not clearly one type or another but fall somewhere on a continuum between these two extremes. For example, a coefficient model can be made to act like a simulation by assuming appropriate changes in the coefficients themselves over time, and by making projections for each year. The choice of a model's structure depends on the resources available to a policy-maker (for example, simulation models tend to be theoretically sophisticated and costly in computer time) and on the type of decisions he faces, since neither structure is inherently "right" in every situation.

Criteria for Review

Model output can be misleading in two basic ways:

(1) variables have the wrong values or

(2) values are given for the wrong variables.

The second type of error can be detected by comparing the structure of the model to the decision it is intended to aid, but the first type is usually more treacherous, since the likelihood of error is difficult to detect without assessing the model's correspondence to the real world.

In Part II below we discuss possible or likely errors which can result from the use of a model having either the wrong structure (usually causes type (1) error) or the wrong parameters (usually causes type (2) errors). A structural error could stem from a variety of situations; some examples follow:

<u>important relationships ignored</u>

Projecting demand for fire services from population estimates overlooks the important considerations of housing density, transportation network, and building type.

<u>same parameter used for two different phenomena</u>

One study uses a population growth rate to project both future population and future commercial activities, although the causes of their growth differ.

<u>dynamics ignored</u>

A constant public-expenditure-per-capita ratio ignores possible effects from changes in either tax rates or personal incomes, just as a constant income multiplier (total income/export income) ignores significant structural changes within the economy over several decades.

<u>relationship represented incorrectly</u>

Most studies represent educational expenditures as a multiple of the number of children, but one <u>adds</u> changes resulting from economies of scale, children's ages, and the taxing jurisdiction's assessed value.

Shortcuts designed to save time and money or to account for a lack of the "right" data can lead to wrong parameters, as in the following examples:

<u>regional parameters used to project subregional changes</u>

Input/Output coefficients developed for a multi-county region become parameters for estimating changes in one particular county.

<u>parameters estimated in the wrong decade</u>

Some models calculate parameters from 1960's business data to project 1970's business patterns.

<u>undersized sample used to calibrate parameters</u>

Estimating a future tax rate from the experience of only a few other cases may give little confidence -- in the statistical sense -- in the estimate.

<u>parameters calibrated from biased or unrepresentative sample</u>

Estimating business activity of a large mining sector from a very small mining sector assumes the increasing size and relative importance of mining does not affect its relationships with other businesses and risks error resulting from choice of an aberrant example of the industry as a whole.

Many models offer advantages and virtues as well, but these are more difficult to categorize. Part II (arranged by topic) and Part III (arranged by model) highlight errors or virtues of interest to policymakers, focussing on (i) testing, (ii) general usefulness to policy-makers, and (iii) contribution to projection methodology. We are especially concerned with (iv) the model's respective exportabilities, but rather than measure these, we raise questions policy-makers should consider before applying each model to a particular situation. A conclusive evaluation on our part would require testing which most studies don't include; most important, since "exportability" depends on the match between the model's properties, the specific conditions in each community, and the particular policy-decisions faced there, it is not a generic property of the model taken alone.

Policy-makers can use the questions we raise, their own common sense, and their familiarity with their locale to determine a model's applicability to their situation.

The first three criteria listed above result from some of the important shortcomings we see in these models as a group. Without testing it is difficult to place much confidence in the results, and without questioning a model's usefulness, we may end up with interesting answers to the wrong questions. In addition, we hope to encourage innovative approaches to modeling by pointing out special contributions to projection methodology.

We can reduce many of these questions to one concern -- how much confidence can a policy-maker place in the results? The answers must reflect the type of decisions being faced, since some decisions require only accuracy while others also require precision. For example, expecting the school-age population to increase by "about 800" may be sufficient for deciding whether to build an additional school; for this decision, the projected figure need not give the exact number of children, but it must be accurate (correct within its claimed range of error). But another decision, such as deciding whether to build the school with 82 or 83 classrooms, requires an estimate with much greater precision. Projection models usually disclaim precision, being more concerned with accuracy. We find it unreasonable to expect much precision from these models and deplore the reporting of results with the <u>appearance</u> of one-part-per-thousand precision (i.e., "808 students").

Format

Our analysis serves two types of needs: policy-makers depending on someone else's projections can use the analysis to quickly understand the issues surrounding them, while analysts making their own projections can use it as a review of the forecasting literature and of some studies in progress.

The study's format allows readers to avoid what is not important to them without missing anything. Each section in Part II focusses on one second-order impact (i.e., employment, population, public services) and includes both an overview and a detailed analysis of the projection methods which have been used. Readers with limited time or interest can read selected overviews for a general understanding both of the approaches used and the problems encountered in projecting each particular impact.

Part III reviews each study, as a whole, to help those "shopping" for a particular model.

Cautions for Consumers

Those purchasing projection studies should be aware that many studies have been low-budget projects, done very quickly (in the interest of "timeliness"), lacking careful consideration and analysis of the problem at hand; few adequately reference their sources of information or report any testing of their models. Defects like these reduce a study's usefulness and hinder the development of better projection methods. Lack of testing is less serious when procedures are either explained or well-enough referenced to allow their replication elsewhere, but too many studies report numbers without explaining their derivation.

Besides these weaknesses, we found several omissions common. Most studies ignore the price elasticity of demand for services and omit procedures for defining "need." Does the cost of providing services affect the quantity of service desired? Experience tells us that if tax bills increase -- especially relative to income -- people decide they don't want so many public services after all. If there is a relationship between service costs and demand, does it change from place to place or from generation to generation? Most important, does everyone "need" the "average" service level? Do they "need" the level recommended by some professional group? How do we decide what people "need" in a particular rapidly growing community in the year 1990?

These questions are neither trivial nor easily solved; purchasers of projection studies expecting to buy models which address these questions and which overcome the weaknesses prevalent elsewhere, should carefully consider the constraints they place on consultants. Projecting second-order impacts costs more time and money than many clients have allowed. Unreasonable constraints on time or funding discourage thorough analysis and reporting, and poor results may be as much the fault of these constraints as of careless work.

PART II: PROJECTION METHODS

Employment

Overview

Employment projections reflect export base theory* by focussing on three types of projection tools: employment multipliers, income multipliers, and input/output coefficients. An employment multiplier** directly transforms predicted energy facility employment into additional total employment. Likewise, income multipliers are used to estimate additional total income which an employee/income ratio can convert into total employment. Models built on input/output interdependence coefficients also include a two-step process, forecasting additional business volume stimulated by energy development and applying employee/business volume ratios to estimate total employment. (Econometric models, a fourth type, depend less on export-base theory and define employment as a multi-variate function of several explanatory variables whose coefficients are estimated with regression equations. This approach overcomes many problems associated with multipliers.)

Three important assumptions form the basis for using these three multipliers: (i) a constant and causal relationship over time between sector activities, (ii) small changes in worker productivity, and (iii) insignificant shifts in the export sector's structure. The most basic assumption, a constant fixed relationship between sectors, ignores the dynamics of the economy (although multipliers which change over time or

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*Export base theory assumes all economic activity in a region to be directed into two sectors: the export sector produces goods shipped out of the region; the local sector produces goods and services consumed within the region. The size of the local sector (also called secondary sector, non-basic sector, and derivative sector) is assumed to be a known function of the size of the export sector (also called basic sector and primary sector).

**Export base employment is that which produces goods shipped out of the region.

with sector size may partially reflect either drastic economic changes (the energy facility itself) or slow responses to change). Models using multipliers implicitly assume small changes in worker productivity, which may be misleading in light of conflicting evidence concerning boomtown worker productivity. For example, if worker productivity actually decreases, requiring more workers than anticipated to mine a ton of coal, then the assumed multipliers will underestimate total employment. In addition, multipliers can't model drastic shifts in the export sector's structure, which may change the relationship between export and non-export sectors and thus render the multipliers incorrect.

To avoid such problems, decision-makers try to choose a source for the multiplier wisely. While some projections use a regional multiplier to estimate employment at a sub-regional level,* others choose multipliers observed in regions with economic structures similar to the affected region's future economy. A model may specify multipliers for an entire economy, for construction and operation workers separately, or for each sector of the economy, but Bender's work suggests that multipliers should be even more disaggregated. He discovered significant differences between multipliers for industries of different sizes and types, which challenge the use of univariate multipliers at all.

The correct estimation of what is exported and imported depends both on the initial division of the economy into export and non-export activities and on "leakage" variables. These last estimate dollars spent outside the region, and their supporting assumptions should consider the region's size, its isolation from other major shopping areas, and its production requirements.

Finally, the period of time covered may affect the model's reliability. Models commonly use multipliers estimated from mid-1960's data and applied to mid-1970's data, to project employment in 1990 or 2000. At some point policy makers must determine if the projection period is different enough from the data source that the resulting error should be reduced by judgmental "fudges."

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*Senechal and Bender warn against use of regional multipliers for estimating at the sub-regional level.

Basic Employment

Most models project employment from the estimated additional export employment. These figures, which energy companies or government agencies provide, usually become the foundation for all remaining projections. Models may use employment data for each year [2, 7, 12, 1, 20] or selected future years [5, 11, 15]. Two models [13, 24] use estimates of the required number of workers per unit of output to transform projected energy output into export employment. [24] also uses company estimates of workers per year. Another [10] uses a multi-variable equation. [27a] presents basic employment estimates for each of eight types of energy development. The data permit users to predict basic employment resulting from a proposed operation.

History shows that basic employment projections can err as commodity prices, energy demand, availability of labor, or weather cause work schedules to shift. For example, the Jim Bridger power plant experienced a construction workforce peak earlier than expected and at more than twice the projected level ([28], p. D-2), a phenomenon sometimes attributed to a shortage of skilled labor and a lower than expected worker productivity. Since further projections hinge on these estimates of additional basic employment, the error cascades through the analysis.

Secondary Employment

Employment Multipliers: Constant Ratios

There are several types of employment multipliers, the simplest being a ratio of total to basic employment calculated at one particular time [2, 7, 12, 14, 32, 20]. The Booz, Allen, Hamilton model [2] lists "high", "medium", and "low" multipliers for several sizes of export sectors, but the vague and inconsistent instructions for choosing the appropriate multiplier and the absence of references make them almost useless. The only explicit assumption holds unemployment constant.

Other models [7, 14, 12, 20, 24] use constant ratios but provide more explanations. One [7] uses responses to a business survey to divide each industry's sales between export and local and calculates an export/local sales ratio. With this ratio they divide employment into export and local sectors and calculate an employment multiplier (local/export employment). A Wyoming model [14] develops multipliers by using a "location quotient", equal to an industry's share of county employment divided by its share of total state employment, and defines export sector industries as those with quotients greater than one. Separating county industries into export and service sectors, the model calculates five employment multipliers (1930-1970) per county which form a trend line used to estimate annual county multipliers for 1971-1983.

Two studies share the simplest approach, taking available employment multipliers and adjusting them judgmentally to reflect regional differences. For example, Luken [12] takes a regional multiplier (1966) and adjusts it for Mercer County, North Dakota, considering the county's closeness to an established trade center and its probable changes in future decades. Another model [20] employs multipliers calculated by other models ([13], [14]) and adjusts them in consideration of tourism, the anticipated speed of energy development, and the different multiplier "strengths" of construction and operation employment.

A similar approach [32] involves calculating multipliers for large, medium, and small cities and adjusting these multipliers by the portion of the basic workers involved in facility construction. The Argonne model [27a] presents constant ratios as an appropriate prediction tool when users have poor input data. A time-lag model allows adjustment of the ratios to more closely reflect actual employment growth patterns.

Employment Multipliers: Regression Coefficients

Regression analysis is used frequently to develop multipliers sensitive to changes in export sector size. The Kaiparowits study [18] reports a thorough development of this procedure, using regression equations to measure the effects of (i) time, (ii) county size, (iii) construction phase, (iv) economic base changes, and (v) proportion elderly on employment multipliers. From the regression coefficients of these variables the study area's probable multipliers are inferred for the present and future.

Although Bender [34, 35] does not actually project employment, he analyzes differences in multipliers by region, industry type, industry size, and industry scale. From regression equations with independent variables reflecting these characteristics, he first predicts secondary employment and then calculates the resulting implied multipliers from each region's export industries. He discovers that multipliers vary by type of industry, by region, by distance from major trade centers, and by scale, especially within the Plains Region. For example, regional multipliers range from .62 to 2.31 for mining and from 1.21 to 3.71 for manufacturing; within a region, basic industries' multipliers can differ by a factor of 6. Multipliers also decrease as industry size increases. Using constant multipliers in situations where the size of the basic industry will increase dramatically tends to overestimate secondary employment; and in the absence of appropiate adjustments, their application to energy development situations could be grossly misleading. [24, 25, 26, 27] apply Bender's methodology [34] when developing employment multipliers. The last also incorporates a time-lag model.

Input/Output Coefficients

The projections initiated by the North Dakota State University team [5, 11, 11a] use input/output interdependence coefficients developed by Sand [36] from 1965 data for the Dickenson, N.D. region, a part of the State Region 8. They project both normal and energy-induced future employment, which they add to get projected total employment. Estimated final sectors' demand, multiplied by sector interdependence coefficients, yields gross business volume; multiplying this last estimate by extrapolated state business volume/total employment ratios determines total employment in Mercer County under current conditions.

To calculate employment stimulated by energy development, the model allocates projected energy company expenditures to sectors and multiplies by coefficients to yield additional gross business volume. Multiplying this figure by extrapolated regional business volume/total employment ratios determines employment stimulated by energy development. While one study [5] explains this employment multiplier procedure and separates construction from operation-induced income and employment, the other [11] barely hints at the multipliers' derivations and completely ignores construction efforts. The former model projects levels in 1980, 1985 and 2000, but the latter makes projections for an "average year," which is less sensitive to errors but less meaningful for planners. However, a conference presentation of the model [11a] includes annual predictions and better explanations of the procedures.

The application of these interdependence coefficients rests on shaky ground. Sand [36] developed the original 30-sector model using 1965 data; and Senechal [37] tested the second version, a collapsed twenty-one sector model, using 1958 to 1968 data for the state and eleven regions. The current version, a thirteen-sector model (reduced according to Senechal's recommendations) uses current data to project gross business volume to the year 2000 [5, 11]. Senechal found the coefficients overestimated changes in a region experiencing a sudden and dramatic increase in oil and gas activity. Thus his tests support use of the coefficients under normal circumstances but suggest the coefficients may overestimate business volume under drastic changes in an industry size.

Research and Planning Consultants adapt the Texas I/O model to offshore oil development [23].

Income Multiplier

Polzin [15] uses regression analysis on 1960-1972 data to project an income multiplier for a three- and a seven-county region, choosing the income multiplier rather than the employment multiplier as being better able to model changes in the economic structure. From projected new export earnings he calculates additional "derivative" earnings, which he multiplies by an earning/derivative worker ratio to yield additional secondary employment from new energy development. He calculates construction and operation income separately, using a construction multiplier half the value of the operation multiplier, and reduces incomes to reflect decreases in farm income.

Capital/Labor Ratio

The BOOM1 model [8] is alone in calculating secondary employment, by applying constant labor/capital ratios to the projected capital investment to determine the number of jobs. It also separates projections into public service and non-public service jobs.

Proportionate "Increase Factors"

A study used in an Environmental Impact Statement [19] projects secondary workers associated with a proposed coal-gasification facility through population and income "increase factors", which have no apparent theoretical base. Employment in certain sectors of the economy is assumed to change at the same rate as either population or income; employment in other sectors, assumed to reflect changes in both population and income, is considered to reflect an average rate. These estimates include only first and second rounds of spending whereas other multipliers reflect all rounds of spending. Separate projections are made for construction and operation periods.

Econometric Forecasting

Krutilla's version of Curtis Harris' model [10] uses regression equations to project the annual total employment change as a function of the change in output, the new level of output, and the capital investment. The model uses very disaggregated data: 99 industrial sectors, 4 governmental sectors, 69 equipment purchasing (investment) sectors, and 28 types of construction. By avoiding simple employment multipliers and by depending on these variables his model probably reflects well the actual decision-making processes determining employment levels in an area.

Miscellaneous Approaches

Several other studies calculate secondary employment but their procedures are obscured in available material. One study [13] uses computer simulation, including a cohort survival model, to determine employment/population ratios. Another study [1] applies Ullman's "minimum requirement method" to develop county multipliers for both military and civilian populations, adjusting multipliers according to past experiences in other regions.

Population

Overview

Most models view population as a function of employment, which they define with various demographic variables reflecting family size, employment patterns, unemployment, and migration. The basic projection procedure uses one or more ratios -- population per worker, employees per household, population per household -- to predict population, but it often omits important variables which could increase the model's accuracy. Specifying population per worker (i.e., the employment participation rate) should take into account the possibility of multiple-worker households, the inmigrants' lifestyles, and the demographic changes accompanying a boom. An important variable, the percentage of jobs filled locally, should also be considered and may vary with the type of development, its location, or its social environment; the percentage ranges, in different models, from 0% to 68% for operation employees and up to 100% for service employees. A related and important variable considers the development's impact on unemployment, which models represent as either a constant level of unemployment, a constant rate of unemployment, or (implicitly) zero unemployment.

Total Population and Subgroups

Employment Participation Ratio

The most straightforward tool for converting employment into population is the employment participation ratio, the ratio of total population to total employees. Three models [20, 33, 11] adjust established employment participation ratios for local population differences (although explanations of their procedures are not always clear), and a fourth study [5] uses historic data in regression analysis to project future ratios. Another [1] (considering the labor force rather than employment) projects the labor force size from historic and comparative data; from these data they determine labor force participation rates used to estimate population.

A similar procedure involves two ratios, an employment/household ratio and a population/household ratio [2, 7, 12, 32, 24, 25, 27a]. [2] and [12] use a constant statewide average household size to project total population. The first study uses an average employees/household ratio for operational employees and assume one worker per family for construction and service employees. The second model [12] uses an employees/household ratio based on similar areas outisde the study region. [7] and [32] apply different ratios of employees/household for each kind of worker. All four assume these ratios remain constant over time. In comparison with other data sources, especially the Construction Worker Profile, [7]'s ratios appear questionable: average family size exceeds that in several other studies by more than one person.

Cohort-Survival Models

Several studies [18, 15, 10, 14, 26, 27a, 30] employ cohort-survival models to project total population be age/sex groups, using separate parameters for construction and non-construction workers and defining migration as the population influx required to fill excess jobs. The Kaiparowits study [18], basing projections on experiences in the Navajo Project in Page, Arizona, calculates population under two extreme assumptions about service industries' response to energy development. One model [15] increases worker productivity according to national trends, and decreases annual farm receipts by $30 per mined acre. Krutilla's model [10], using four age groups and two race categories, projects population from a regression equation with birth, death, migration, wage and labor-surplus variables.

The use of the age/sex labor force participation ratios in these cohort-survival models has an advantage over other types of models by allowing population and labor force to change at different rates; Polzin's results show labor force increasing faster than population, reflecting an increasingly young population and multiple job holders per family. A weakness in the approach stems from its definition of migration as a function only of the difference in total labor supply and demand, which may ignore mismatches between labor force skills and employment needs.

Population Allocation: Gravity Models

Besides projecting total regional population, several studies allocate population to particular local governments through the use of a gravity model [19, 2, 12, 1, 11, 20, 26, 27b]. These models generally assume population increases are related directly to city size and inversely to city distance from point of employment. The first model [19] uses a ratio of city populations, weighted by distance from the facility, to distribute construction and operation employees. Two others [2, 12], using the Booz, Allen and Hamilton gravity model, include variables for distance, city size, and importance of work-related trips, and allocate workers to a single city within the "community." A Wyoming model [20], considering only city sizes and distances, can distribute migrants to more than one city within the region, and Arthur D. Little's gravity model [1] allocates population under three different policy assumptions. A North Dakota model [11] distributes population among school districts according to each school district's current size. Other models [24, 32] combine several of these approaches. [32] allocates workers according to commuting distances, alternative residences, physical barriers, and government and company location policies. [24, 25, 26, 27b] use an econometric submodel to predict spatial distribution from (i) assumed housing preferences, (ii) commuting preferences, and (iii) community services -- all constrained by income and housing availability.

Additional versus Total Population

Studies differ according to the completeness of their impact considerations. Studies considering only inmigrating population resulting from a major energy facility do not present a picture of the total population in a future period [18, 15, 20]. Another method adds new employment to previous employment and projects total population from total employment, which allows for possible changes in the original population [1, 10]. The Argonne models [24, 25, 26, 27] combine baseline and inmigrating population estimates to determine the total new population. The baseline estimates reflect the changes in employment opportunities.

Service Impacts

Overview

The majority of models predict service demands by multiplying population estimates by per capita "adequacy" standards like "hospital beds per 1000 population" or "policemen per person."*

The models' different sources of standards -- those recommended by professionals; the study area's observed status quo; or those observed in areas similar to the study area's anticipated condition -- reflect different definitions of "adequate"; but the studies present little evidence to support one definition over the others. Projecting future service levels from these standards risks inaccuracy, since variation in population behavior and attitudes threaten the validity of the standards' underlying assumptions. "Adequacy standards" supposedly measure the "need" for certain services, but social custom, the price elasticity of demand, and regional differences can render any of these standards invalid. For example, if tax rates increase will public service demand decrease in response? As incomes increase, do demand levels change? Can "need" act as a proxy for effective demand? Most studies fail to address this kind of question; while some mention it as a problem, none seriously addresses the problem of defining "need" or confidently suggests ways to handle it.

Three often overlooked variables -- current service utilization, residential settlement patterns, and population age distribution -- may have significant impacts on predicted demands for services and infrastructure. Failure to consider current service and facility utilization may result in an over-estimation of the future needs. The settlement pattern, including housing density and mix of housing types (i.e., multi-family, single-family, or mobile homes) influences the demand for public infrastructure such as schools, roads, sewage lines, and fire stations;

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*In this critique, as in the models reviewed, the term "demand" does not refer to the demand function but to the quantity or level of services actually provided. All models reviewed either fail to consider any shift in the demand/price functions or (implicitly) assume totally inelastic demand.

and the population's age distribution strongly affects the demand for housing and educational services. Even the models using these three variables display little consistency in either their design of functions or their specification of parameters. At one extreme, cohort-survival models use the most detailed approach and divide the total population into many age categories which change over time by specified rules; at the other extreme, some models simply assume a percentage of the population to be school age, their choices differing by as much as ten percentage points.

Housing

Most models estimate additional housing demand from (i) number of households, (ii) an assumed distribution among single-family, multi-family and mobile home units, and (iii) separate calculations for construction and non-construction workers [2, 7, 11, 12, 18, 32]. Leholm et. al. [11] simply assume that additional housing units produced within the region will equal the number of new families, which stops short of any serious policy questions since it implicitly assumes no one commutes, no one brings his home, and no homes are currently available. Four models [32, 19, 8, 7] include more detail, determining separate housing utilization rates and housing demands for each type of family. A similar but more detailed procedure [18] determines the number of households by applying an adults/household head ratio to the adult-aged population cohorts, which can reflect changes in population age structure over time. The model also adjusts for the local service sectors' response time.

Two models [2,12] use a statewide housing vacancy rate and current percentages of housing types to project future demand from non-construction workers, assuming permanent housing supply for construction workers shows a six-month lag but never exceeds the eventual demand by non-construction employees; mobile homes meet an "excess demand" by construction workers. Luken [12] applies the housing type proportions reported in [2] to urban areas and assumes 70% of rural housing will be permanent.

Three models [2,18,1] show more sensitivity to the permanent housing demand factors. In the first two models the lag in housing supply increases with the community's perception of the development's lack of "permanence." In the initial development phases, the community (both previous and new residents) will doubt its permanence and will be reluctant either to expand services and businesses or to invest in a permanent home. As it becomes more evident that the development is long-termed, businesses will expand and new employees will seek more permanent housing. The third model [1], with the most useful housing demand analysis, calculates the number of households (from a population per household ratio) and develops housing budgets which they compare with the expected housing supply costs. From this comparison they determine (i) the necessary price distribution of housing supply, (ii) the number of families which can afford only to rent, and (iii) the portion of families unable to afford housing without assistance.

Education Services

Increased demand for educational facilities is an immediate problem for most local governments experiencing rapid energy development. While there may be delay in needs for other public services, public schools experience pressure for expansion as soon as new employees relocate their families. Predicting educational demand requires (i) projected school-age populations; (ii) pupil teacher ratios; (iii) pupils-per-classroom ratios; (iv) square feet per child or per classroom ratios and (v) pupils per school.

Several studies employ very straightforward procedures [2,12,1,11,19, 33]. Using average state percentages (held constant over time) they estimate elementary and secondary school enrollments from projected population, and new teachers and classrooms are estimated as a function of student increments (ranging from 17 to 30 students per teacher). Three models [21,7,2] alter these procedures for construction workers, using different estimates of the number of school-age children per family.

Studies with a cohort-survival model [9 and 15] add population in the appropriate age categories to determine the number of children in each grade level. [15] applies per pupil ratios to estimate numbers or classrooms and teachers.

A unique approach [10] estimates the yearly school-age populations in both primary and secondary grades from simple population ratios. Service expansion is assumed to take place when one year's school population exceeds the previous peak in school population, thus cleverly incorporating a measure of facility capacity.

Water and Sewerage

[18, 2, 9] project demand for water and sewerage services from either average of maximum per capita measures, while others [1, 9, 21] base estimates for water distribution systems on water consumption and housing density assumptions. Models [9] and [18] determine sewerage needs from water needs. [1] spatially distributes housing units which water/sewer engineers use to lay out water and sewer lines; their designs reflect constraints from topography, population settlements, infrastructure, and density.

[23] and [28] pay special attention to water demand as a limiting or critical factor in development.

Other Public Services

Other public services and facilities, such as police and fire protection, tend to be estimated on a per capita bases. One approach [4] applies well-known per capita standards to projected construction and non-construction populations to estimate both facility and service demands, taking care not to use per capita standards where they may be misleading. For example, without either a physical plan or detailed demographic data, it may be misleading to project staffing levels for mental health, welfare, fire, roads and streets, public transportation, and recreation, since population size does not alone determine use of these services. The authors display adequacy and cost standards which might be applied and stress use of these standards as only beginning points, assuming that final projects will include analysis of, and discussions with the local population.

Three models [9, 12, 33] use per capita service standards either recommended by the state or computed for areas similar to the future energy development area. [9] uses simple per capita coefficients for some services but adjusts them for others, i.e., fire and police protection, libraries and health service, where demand is not a simple function of population. For example, required water flow (for fire fighting), town layout, and population determine the fire demand coefficients. The model calculates service demands only for the year of peak population. In the second study these standards measure current capacity and "excess demand" for various government services under three alternative development scenarios; the third just measures additional demand, assuming that half the employees live in the primary area.

A more involved study [18] adjusts average levels of police, fire and general employees per capita in prototype U.S. cities for regional differences, various growth expectations, and inflation to predict demand in 1986.

The BOOM1 model [8] projects public service facility demand from estimated population levels and from a measure of public service facility shortages, with the latter reflecting differences between estimated and constant (standard) ratios of public service capital per capita.

Argonne models [26, 27b] use adequacy standards, developed for them by Real Estate Research Corporation, which quantify "average acceptable standards" for each of ten services and 24 community types. Standards are expressed first as service needs per unit of population, students, or dwelling units and eventually are converted into per capita estimates.

Retail Service

Income

Most models represent demand for private services as a function of personal income and population size, basing income projections on increased wages and salaries of new employees. The simplest approach [2] multiplies the number of basic and secondary workers by mean basic and secondary earnings, respectively, summing to get total new income. A more refined procedure [7] employs the number of new employees and earnings in each sector of the economy to calculate each sector's new earnings, applying 1972 income levels adjusted for 4% annual inflation and assuming no sector loses income or employees. The Kaiparowits study [18] includes even more detail, assuming worker productivity increases over time, inflation rates differ for construction and non-construction worker earnings, and that salaries differ significantly by job type. A simulation model [15] defines secondary worker per capita earnings as a positive linear function of migration, and projects total new income with an income multiplier. Another model [12] also using an income multiplier, chooses a <u>regional</u> multiplier to project <u>county</u> income, which we consider a questionable practice. The BOOM1 model [8] uses projected wage rates and numbers of workers in various sectors of the economy to calculate permanent personal income; it considers temporary personal income separately.

Retail Service Levels

Projections of retailing generally represent sales as a portion of personal income and retail space as proportionate to sales. In predicting retail sales volume from personal income, models often use a percentage of personal income -- 50% to 60% -- spent on retail goods [7,12] and may adjust these percentages for retail "leakage" [8,2]. [32] adjusts 1970 and 1975 retail sales per capita figures for specific local conditions and for high, medium, and low development scenarios (criteria for adjustments not specified). [31] defines retail sales per capita as a function of median family income, percent urban population, and county "recreation potential." A different approach [11, 11a] calculates the retail sector's sales volume by applying interdependence coefficients to energy company investments. Generally a retail space/retail sales ratio converts these estimated sales into space requirements; but one model [18] uses several ratios to calculate space requirements by type of retail good, and another [2] offers predicted values for wholesale sales, using wholesale/retail ratio.

The Arthur D. Little study [1] includes variables for both population and city size when predicting retail service demand, but it uses different parameter values for "convenience" and "shopping" goods: the sizes of both convenience and shopping outlets are functions of population, but the number and location of outlets differ by population concentration, with the "commercial" outlets dispersed evenly throughout an area and the "shopping" outlets located in large population centers. This approach ignores the commonly assumed retail services' demand factors, but without testing we cannot conclude whether population or income standards are more accurate; a combination of both standards may be the most appropriate approach.

BOOM1 [8] combines several techniques: from projected total personal income it estimates retail expenditures, which it multiplies by a capital investment/retail expenditures ratio to yield the "required" retail and service facility investment. "Additional" retail and service construction is the difference between the current and the "required" facility investment.

Public Revenues and Expenditures

Overview

The projections of most interest to policy makers, politicians and taxpayers concern expected government costs and revenues. Regrettably, these estimates usually deserve little confidence since they are often the final figure in a cascade of forecasts offered without significance levels or confidence intervals. The most common reliability test determines the outcomes of several different hypothetical development or settlement patterns, but surely calculations would be more valuable to policy makers with some measure of each case's range or variance.

Confidence in these calculations can only come from careful analysis of the assumptions used. Revenue projections, depending on assumptions about changes in tax rates, in assessment rates, and in the tax base, are seldom "exportable" since these vary with the political and social climate of each area. Projections of government expenditure usually employ a constant cost standard, such as cost/pupil or cost/square foot, but some models incorporate assumptions about (i) inflation rates, (ii) productivity changes, and (iii) changes in unit costs for such items as fuel and land.

An important aspect of both revenue and cost forecasts is the jurisdictional level of projections. Those made for a state or multi-county region yield average estimates but hide the fiscal management problems faced by particular local government officials, while projections specifying lower levels of government point out not only the size of the revenue pie but also the distributional problems. Unfortunately, the poor quality of available data seriously reduces both the accuracy of local level projections and their ability to foreshadow numerous serious impact problems.

Revenues

Property Tax

A number of studies forecast tax revenue from current tax rates but differ in their estimation of taxable property value [2, 12, 32, 33, 19, 1]. The first four models use current assessment ratios and let market value equal construction costs (the third uses 80% of construction costs). Another [19] defines permanent home market values as a linear function of mobile home values. [1] projects taxable value from historical trends. A second approach [18, 7, 15, 10, 19, 32] forecasts the tax base from per unit estimates of property's taxable or market value: value/mile of rail, value/unit of production, equipment value/employee, construction costs/square feet, costs/acre, property value/person, etc. The Kaiparowits study [18] uses such ratios but adjusts their values for a 1.7% annual inflation rate. A North Dakota model [11] displays a third approach, defining taxable values as percentages of investment, using a different percentage for each type of property.

Few models adjust taxes for response time lags, except those which project impacts just for the facility operating phase [18]. One multi-state study [4] omits explanations of tax base projections but discusses each state's policy. The discussion focusses on causes of tax revenue lags and includes an example of annual education revenues and expenditures. The BOOM1 model [8] reflects some time lags in tax revenue estimations by including the value of commercial capital, which changes over time, in its market value calculations.

While most models build revenue projections on current tax rates, some estimate future tax rates from past trends [18,11,15]. Another approach [8] holds the assessment ratio constant and adjusts tax rates to yield required revenue, i.e., debt payments, operating costs, and 40% of new construction costs. Krutilla's model [10] uses several tax rates to test the results' sensitivity to this parameter. [31] avoids tax rates entirely, defining property tax revenue as a function of total personal income.

Sales Tax

Sales tax revenue projections follow procedures similar to property tax revenue predictions -- multiplying a tax rate by the projected base, sales value [19, 31, 32]. One method [18] employs limited sensitivity testing both by using three sales volume assumptions and by varying tax rate and base combinations. An input/output model [11, 11a] forecasts both recurring and non-recurring sales tax revenues by applying tax rates to estimated gross business volume in appropriate business sectors. Non-recurring revenues result from new construction: applying the taxable sectors' inter-dependence coefficients to 22% of business volume (the portion representing non-recurring new construction) yields the dollar change (tax base) subject to current tax rates.

Income Taxes

Those models including income taxes simply apply constant tax rates [15, 11] or estimated future tax rates [18] to projected income levels. A different approach [10] averages income taxes paid in each income category, allocates workers to these categories, and adds these estimates to yield income tax revenues.

Transfer Payments

Several models include state subsidies to local government. [10] measures state transfers of coal development revenue. Using the 1973 transfer payment fraction of local government revenue, [8] assumes about half of local revenue will come from this subsidy. [9] and [13] use per capita estimates for measuring transfer payments; the former also predicts revenue sharing funds from a complex submodel simulating Tennessee's revenue sharing process.

Royalties and Severance Taxes

Minerals on state property are extracted under leases; the lessee pays the state a roylaty set at a fraction of production value or at a fixed sum per ton. Minerals extracted on federal property involve similar royalty payments to the federal government, of which the state receives a fixed share. Mining on private and public land is often subject to a severance tax, also specified either as a fraction of value or as an amount per unit. One study [18] projects royalties from lease terms and estimated tonnage; severance tax proceeds are predicted as an assumed price per ton multiplied by the tax rate, an amount of revenue per ton, or a multivariate equation [18, 15].

Expenditures

Projecting government expenditures almost always depends on costs per capita or costs per service unit. Simple, aggregated projection procedures are often used for operating expenditures, multiplying average expenditures per person by the number of persons [14, 15, 2, 18, 31, 32, 21, 7]. [31] defines per capita expenditure as a function of total personal income in a county and a "growth in service factor," which was not explained explicitly. Its estimation of education expenditures reflects the local share of the costs, a one-year time lag and local taxable property value. [24] develops a more complex ratio which reflects the indivisibility of some services and the nature of public consumption. More thorough models also consider current service capacity [2, 12, 7, 32]. Two of these [2, 12] define construction phase public expenditures as 90% of the level expected during operation and others [9, 11] use per capita cost controlled for city size. Some studies [7, 9, 32, 12, 11, 19, 10, 21] project at least a portion of expenditures from estimated service levels rather than just expenditures per capita figures.

One technique divides services into several levels before calculating costs (e.g., parks -- neighborhood, community and regional; water and sewer -- local, areawide), defining different unit cost parameters, both operating and capital, for each service level [1, 30]. For example, in [1], local water and sewerage costs are projected from infrastructure needs determined by model output and engineer's infrastructure designs. Costs estimates include considerations of current infrastructure, financial source, timing of financing, residential density, and local distribution of families.

The BOOM1 model [8] uses per capita measures for capital and operating costs (taken from [32]) to predict public facility construction, debt, and operating expenditures. Another model [3] uses a similar approach which reflects construction costs and unit operating costs.

A simulation model [10] estimates per capita revenue and uses it as a proxy for non-education expenditures, assuming tax rates are defined as a function of (i) population, (ii) population density, (iii) personal income per capita, (iv) taxable property value and (v) area.

Only a few models [1, 9, 10, 18] consider, even in a limited way, the effects of inflation and changing price-elasticity on public expenditures. We think forecasts should seriously consider effects from demand changes and should test the models' sensitivity to different per capita demand measures.

Public Revenue/Expenditure Comparisons

Several studies take expenditure and revenue projection one step further by comparing total expenditures and revenues. Their authors recommend caution when using these comparisons, since their uncertain assumptions and poor quality of data make them a risky basis for deciding on a development's long run value. Polzin suggests readers use his estimates as nothing more than "ballpark" figures, and we suggest similar caution with other projections -- unless they involve improved methods and more testing.

The simplest fiscal impact models compare projected total revenues and expenditures for various levels of government at several points in time [2, 11, 12, 15, 30, 31, 32]. One model [11] compares only the <u>change</u> in revenues and costs for an "average" year, ignoring impacts already expereinced in the construction phase. [32] compares expenditures and revenues in only the expected peak years (for each of three development scenarios). Another model [15] projects only 1980 and 1985 county and state fiscal impacts using OBERS projections [44] as part of the baseline figures (i.e., without energy development); expenditures reflect all operating costs. Luken [12] estimates separate operation and construction effects for the state, county and various cities in the mid-1980's. One cost/revenue comparison [2] looks at different levels of government, adjusting capital investments for interest costs, and calculates present values.

The local impact model by Bruckner and McKay [3] employs constraints for municipal expenses and income: expenses in any one year are less than or equal to income in that year' and the revenue structure and capacity determine expenditures. BOOM1 [8] uses a great variety of variables to depict the municipal finance impacts, including public construction, bonding, assessed valuations, operating costs and tax rates. Planned testing of these models (currently in development stages) will allow better evaluation of their validity, but currently available reports allow their examination.

PART III: PROJECTION STUDIES

Arranged by projection study, this section summarizes the distinguishing characteristics of each model. It addresses five types of questions for each study:

Design Purpose -- Why was the projection model developed?

Special Features -- What sets this model apart from the others? What are its special contributions to projection methodology?

Tests -- What testing, if any, do we find that establishes confidence in the model's application and results?

Exportability -- How successfully can this model be applied to a different setting or development situation? What questions should be answered before a new user can apply the model?

Usefulness -- How can this model serve the policy-makers' needs? What questions might it address? How easily can it be replicated and what costs (time, skills, dollars, etc.) are involved?

The descriptions should be used in conjunction with Figure 4 which tabulates the variables, the geographic levels, the projection time periods, the development phases, and the various submodels found in each document.

[1] Arthur D. Little, Inc. Analysis of Selected Impacts of Trident-Related Population Growth in Kitsap County. Seattle: Central Puget Sound Economic Development District, December 1975.

[1a] Horsley, John C.; Isaki, Paul S.; Jensen, Kenneth A. The Trident Submarine Comes to Kitsap County: An Analysis of Secondary Community Impacts. A paper delivered at the Tenth Annual Pacific Northwest Regional Economic Conference, Victoria, British Columbia, May 7, 1976. Seattle: Central Puget Sound Economic Development District, 1976.

Design Purpose

Estimates effects of construction and operation of U.S. Navy's Trident Submarine Support Facility in Kitsap County, Washington.

Special Features

Housing demand projections consider "affordability" and reveal the portion of families unable to afford housing without public support. Use of computer mapping subjects housing and public infrastructure development to topographical and social constraints; public infrastructure costs reflect both unit costs and borrowing costs. Also thoroughly considers differences in two populations, civilian and military, and estimates all results for four residential density patterns.

Tests

Changes assumptions concerning residential density and settlement patterns and compares results to projections from current trends. Another test compares employment projections to a special census.

Exportability

Particularly suitable to other situations owing to considerations of (i) local effects, (ii) changes in small time periods, (iii) different populations (military and civilian), and (iv) natural and man-made development constraints. While actual quantitative values for assumptions may differ elsewhere, precedures for reaching assumptions and variables considered are exportable.

Usefulness

Documents and explains assumptions and procedures and indicates thorough and careful work. Despite limited testing, the projection procedures appear useful for policy-makers. Output format is ideal for testing effects of alternative local and county policies on costs, timing of financing, and supply of revenue; and the reasoning behind assumptions and procedures increases confidence in the output. Using the model requires extensive computer-mapping and statistical skills, but data requirements are not complex.

The entire projection procedure, as presented in this document, could not be replicated without technical staff accustomed to computer-mapping and economic projections. [1a] provides easily understood overview of problem and model's approach.

[2] Booz, Allen, and Hamilton, Inc. A Procedures Manual. Billings, Montana: Old West Regional Commission, 1974.

Design Purpose

Intends to standardize impact study techniques by developing projection methods applicable in any situation.

Special Features

Work-book format proceeds from a description of input data needed to variety of formulae, output of one becoming input for another. In view of application problems that have arisen, planners at Old West Regional Commission (OWRC) do not recommend its use by those unfamiliar with projection methodology. Client has no plans to correct manual's shortcomings for less sophisticated users.

Tests

Produces "answers" to questions but contains no documentation to support validity in application. Two other documents (Evaluation of the Procedures Manual, Application of the Procedure Manual) summarize application to Wheat-Land, Wyoming in 1975, and suggest possible revisions.

Exportability

OWRC has no plans to revise the Manual and lately has come to question this approach to the problem of evaluating impacts as too general.

Usefulness

Excludes several important elements: estimations of tax rates and per capita standards over time; changes in per capita demand levels over time; inflation; and effects on pre-facility population. Contains dangerous typographical errors, and inconsistencies in the input data's dates and geographic bases. Assumption of locating coal facility in fastest growing school district limits the Manual's application. We trust it principally as a framework for more detailed analysis, and hold it entirely insufficient for developing impact projections for decision-making.

[3] Bruckner, Lawrence A. and McKay, Michael D. A Local Impact Model. Los Alamos Scientific Lab Report LA-6665-MS. Los Alamos, New Mexico: Los Alamos Scientific Laboratory, January 1977.

Design Purpose

Estimates impacts to determine construction timetables that permit orderly community growth.

Special Features

Linear programming model, to optimize construction timetable variable. Defines "employment multipliers" as the "units" of one industry needed to support "units" of another. Constraints and objective functions can be varied by user.

Tests

Sensitivity analysis for arbitrary values of parameters and objectives presented.

Exportability

Cannot be determined; designed for general applicability.

Usefulness

Objective function in inconsistent units; parameters for a real application must be determined. Linear programming format probably oversimplifies the real phenomenon portrayed. Variables highly aggregated.

[4] [Anonymous]. Anticipated Effects of Major Coal Development on Public Services, Costs and Revenues in Six Selected Counties. Bureau of Reclamation, Billings, Montana and the Center for Interdisciplinary Studies, Montana State University, Bozeman, Montana, 1974.

Design Purpose

Demonstrates possible impacts in six non-adjacent counties (in three states) and their major cities from three levels of energy development.

Special Features

Emphasizes limitations of national and regional standards and recommends them as a guide in determining impacts, distinguishing actual needs from needs estimated from average data. Recognizes that certain service needs are not linear functions of population, and that for other service projections we lack comparable historical data. For these cases, addresses impacts which could influence costs, calling attention to variables important in planning. Projections cover three coal development scenarios defined by Northern Great Plains Resources Program.

Tests

None reported.

Exportability

Explicit projection techniques may be exportable since they depend on well-documented national and regional per capita standards. Service demands not direct functions of population, such as fire, mental health, or welfare services, discussed and accompanied by "adequacy" standards and cost standards.

Usefulness

Although most projection procedures cannot be replicated, the excellent documentation of service "adequacy standards" could benefit policy-makers. Projecting service needs requires minimal skills and time, given population projections. Choice of projection points (1980, 1985, 2000) limits policy-makers focussing on immediate service demands, despite separation of construction and operation activity.

[5] Dalsted, Norman M.L.; Leistritz, F. Larry; Hertsgaard, Thor A.; Frasse, Ronald G.; Anderson, Richard. Economic Impact of Alternative Energy Development Patterns in North Dakota. Prepared for Northern Great Plains Resources Program, June, 1974.

Design Purpose

Evaluate Western North Dakota's local economic, employment, and population growth impacts from NGPRP coal development scenarios.

Special Features

Uses of input/output coefficients to determine total population, explaining in detail the process of allocating development expenditures to sectors of the economy; predicts impacts for three development scenarios defined by Northern Great Plains Resources Program (NGPRP).

Tests

Senechal [37] tests the model at the regional level (not at the county level) and implies it is inappropriate for drastic changes in the mining sector. Further tests compare 1958-1973 input/output estimates to Department of Commerce personal income records, but the study reports no significance tests. Regression analyses not explained in detail; while the assumptions seem plausible, we have no measure of their validity.

Exportability

Dependence on detailed regional input/output coefficients limits model application to regional impact studies (Sand [36] warns against their use in subregional areas).

Usefulness

Given reliable interdependence coefficients, can be replicated by anyone familiar with regression analysis, but some aspects reduce its usefulness. Choices of average years and of regional study area limit application to general analyses of secondary impacts, and problems may arise from the choice of different bases for calculating baseline and impact parameters. Using input/output coefficients ignores major structural changes in factors of production. Assumes additional population is a function of additional business volume, overlooking changes either in proportion of workers locally-hired or in unemployment.

[6] Development Research Associates; Gruen Associates. Housing and Community Services for Coal Gasification Complexes Proposed on the Navajo Reservation. "Chapter III." Framington, New Mexico: El Paso Natural Gas Company and Western Gasification Company, 1974. Available from El Paso Energy Resrouces Company, Framington.

Design Purpose

Overall study design unknown; chapter uses economic system model to characterize hypothetical new town serving coal gasification project.

Special Features

The model differentiates impacts on two ethnic groups, Navajo and Non-Navajo, and presents useful explanation of procedure.

Tests

The portion of the model at our disposal reports no testing.

Exportability

"Chapter III" explains, in great detail, derivation of assumptions but not particular projection methods; exportability questions require familiarity with the entire model.

Usefulness

Approach to a very difficult and politically sensitive problem -- differentiating impacts on two ethnic groups -- should be useful to policymakers facing similar situations.

[7] Doran, Richard K.; Duff, Mary L.; Gilmore, John S. Socio-Economic Impacts of Proposed Burlington Northern and Chicago North Western Rail Line in Campbell-Converse Counties, Wyoming. Denver, Colorado: Denver Research Institute, May 1974.

Design Purpose

Meet Bureau of Land Management's need for socio-economic impact analysis of proposed railroad; background for an Environmental Impact Statement.

Special Features

Surveys provide data for deriving employment multipliers.

Tests

Comparative tests find population projections similar to results in other studies, but testing of individual assumptions is absent.

Exportability

Demographic assumptions should be tested before application elsewhere.

Usefulness

One could replicate calculation procedures but not derivation of crucial assumptions; operating requires only minimal skills although surveying energy companies (for employment multiplier data) could be both costly and time-consuming.

[8] Ford, Andrew. Summary Description of the BOOM1 Model. LA-6424-MS, September 1976; User's Guide to the BOOM1 Model. LA-6396-MS, August 1976, Los Alamos, New Mexico: Los Alamos Scientific Laboratory.

Design Purpose

General model for testing various public policies' impacts on boomtowns, such as loan guarantees and front-end capital grants

Special Features

Systems Dynamics model [38, 39], omits detailed service expenditures, concentrates only on variables determining overall costs -- bonding rates and capacities, average life of public capital, public construction cost increases, etc. Documents' clarity and completeness exemplify excellent reporting procedures, allowing someone completely unfamiliar with the process to understand the model thoroughly.

Tests

User's Guide displays sensitivity tests of five important assumptions; the model is undergoing field tests, some assumptions claimed to be "generic" (applicable to any town in any state) may be specific to locations or type of energy facility; field tests should resolve such questions.

Exportability

Several assumptions may affect exportability. User's Guide references the parameters chosen; several differ from those used elsewhere. Example: BOOM1 assumes labor force participation rate remains constant whereas [18] shows a significant change in this rate. Many parameters reflect the Rock Springs experience, especially the Gilmore/Duff "vicious cycle" -- poor living conditions, worker turnover, decreased worker productivity, increased public finance problems, etc. Other researchers challenge Gilmore/Duff hypothesis on the grounds that (i) their analysis is superficial, (ii) it incorrectly assumes causation among variables with high correlation, and (iii) it ignores Rock Springs' atypical social history. Unfortunately, tests of parameters will not call attention to possible weaknesses of this type. Can easily remove present dependence on Gilmore/Duff vicious cycle.

Usefulness

Although not ready for application, an innovative approach to predictions of local impacts. Specifically addresses effects on local governments, including serious consideration of construction period; while it does not specify particular service needs (i.e., number of doctors), it can analyze basic policy questions. Both Summary Description and User's Guide document assumptions and procedures well enough to be understood by patient laymen. Although data requirements are no more extensive than in other studies, model implementation requires both computer skills and the ability to tailor it to a particular locality. BOOM1 has been successfully replicated by other research teams.

[9] Intermountain Planners and Wirth-Berger Associates. Capital Facilities Study; Powder River Basin. Cheyenne: Wyoming Department of Economic Planning and Development, 1974. Received from Cumin Associates, Billings, Montana.

Design Purpose

Develop methods and information to help county officials plan for mineral development in the Powder River Basin.

Special Features

Predictions for public facility and service demands and costs reflect current capacity, utliization and future usage rather than only population. School expenditures function of school district size, predominant grade level, and district wealth. Predicted fire service demand based on fire flow and town layout.

Tests

No testing reported.

Exportability

Appears exportable but per capita coefficients questionable outside Powder River Basin. Predicting fiscal impacts with iterative reassessment process should be highly exportable.

Usefulness

Simple and inexpensive approach; appropriate for staff with limited technical skills. Provides indicators of possible service delivery and finance problems. Explicitness permits easy replication, given expected population and production data. Dependence on historical per capita standards may reduce accuracy where substantial population changes expected.

[10] Krutilla, John V. and Fisher, Anthony C., with Rice, Richard E. Regional Economic and Fiscal Impacts of Energy Resource Development: A Case Study of Northern Great Plains Coal. Washington, D.C.: Resources for the Future, Inc., 1976.

Design Purpose

Reveal short-run problems accompanying shifts in energy supply by measuring economic, demographic, and fiscal impacts of Western coal development strategies.

Special Features

Recursive econometric model; overcomes several common shortcomings in other models: it (i) captures dynamic changes, (ii) avoids dependence on development company estimates of employment, (iii) addresses policy problems through sensitivity tests, (iv) concentrates on accuracy rather than precision, and (v) measures impacts on per capita rates and tax rates from changes in income level and in other variables.

Tests

Authors report extensive sensitivity and significance tests (lending confidence to the results), and explain calibration of parameters, direction of possible errors (i.e., over- or under-estimates), limitations of results.

Exportability

While values of parameters may vary from situation to situation, structure and procedures represent development impacts elsewhere. Omits detailed projections, such as service cost and projected service levels, which reduce exportability of other models.

Usefulness

Assuming availability of a staff at ease with econometric models, could be replicated easily from included references and explanations (only a few simple parameters are inadequately referenced). Possible drawbacks are avoidance of detailed cost estimates and brief consideration of municipal impacts; implied criterion throughout is preference for accuracy over precision.

[11] Leholm, Arlen G.; Leistritz, F. Larry; Hertsgaard, Thor A. Local Impacts of Energy Resources Development in the Northern Great Plains Region. Denver Colorado: Northern Great Plains Resources Program, September 1974. [See also 11a and additional studies III- .]

Design Purpose

Aid state and local decision-makers by analyzing Mercer County, North Dakota socio-economic impacts from various coal development strategies.

Special Features

Uses input/output interdependence coefficients and projected gross business volumes to predict impacts from two (of three) N.G.P.R.P. development scenarios; apparently extends [5] but includes fewer references and explanations.

Tests

Testing limited to projections using different residential settlement patterns. While per capita measures specified for city size and overall robustness help minimize errors, application of regional interdependence coefficients to single county economy make all results questionable.

Exportability

Dependence on input/output interdependence coefficents and absence of references reduces exportability especially to areas smaller than a multicounty region.

Usefulness

Results may be helpful when deciding general policy questions but have little value for more specific questions. Predictions reflect a county's "average annual" impacts during the operation period, and cannot address either local or construction-period impact problems. (Claims to consider only operation phase, but projects revenues resulting from facility construction.) Discusses current capacity of public services and facilities, but omits these considerations from predictions. Basic structure, excluding estimation of coefficients and ratios, could be replicated from this study's explanation. However, study shows little sensitivity to probable errors. Without further testing we place little confidence in results.

[11a] Leholm, Arlen G.; Leistritz, F. Larry; Hertsgaard, Thor A. Fiscal Impact of a New Industry in a Rural Area: A Coal Gasification Plant in Western North Dakota. Paper for presentation at the Seventh Annual Meeting, Mid-Continent Section, Regional Science Association, Duluth, Minnesota, June 13-14, 1975. Fargo, North Dakota: Department of Agricultural Economics, North Dakota State University, 1975.

Design Purpose

Explains [11] and includes some improvements.

Special Features

Later version of [11]; makes annual predictions for both construction and operation phases, overcoming some shortcomings of the earlier study.

Tests

Reports no testing.

Exportability

Same exportability problems as [11].

Usefulness

Changes mentioned above, plus additional explanations and references, increase usefulness; using both studies together [11,11a], could be replicated, if one has access to or can determine input/output interdependence coefficients. Substantial recent improvements implemented through North Dakota's Regional Environmental Assessment Program (REAP). See Additional Studies III-45.

[12] Luken, Ralph A. Economic and Social Impacts of Coal Development in the 1970's for Mercer County, North Dakota. Prepared by Thomas E. Carroll Associates. Denver: Old West Regional Commission, 1974.

Design Purpose

Provide prototype analysis of coal development economic impacts using [2]'s format and assumptions; emphasize public sector changes.

Special Features

Focusses on local governments and considers impacts during construction period.

Tests

Includes sensitivity tests of residential settlement parameters and validity tests of gravity model (without adjusting the latter for errors); many assumptions come -- untested -- from [2], a model of questionable quality and validity.

Exportability

Increases exportability by making adjustments for inadequate historical data, but several assumptions may be inappropriate elsewhere. Example: projecting government expenditures during construction phase assumes no additional capital costs and lower than average operation costs per capita; particular state and local policies, fiscal bases and expenditure patterns could render these assumptions grossly inaccurate.

Usefulness

Framework for analysis, lending itself to policy questions, considers each level of government and tests alternative settlement patterns which could be affected by governmental control; but cost/revenue comparison for mid-1980 rather than for each year overlooks initial government fiscal problems. Detailed reporting of projection methods, data sources, and procedures for deriving assumptions facilitates replication elsewhere.

[13] Matson, Roger A. and Studer, Jeanette B. Energy Resources Development in Wyoming's Powder River Basin: An Assessment of Potential Social and Economic Impacts. Prepared by the Wyoming Water Resources Research Institute. Denver: Northern Great Plains Resources Program, May 1974.

Design Purpose

Provide other NGPRP analysts with population projections (Powder River Basin) under NGPRP development scenarios.

Special Features

Includes ex post facto analysis of other projection studies; Wyoming Water Resources Research Institute currently employs two versions of this model to address impact problems.

Tests

A sensitivity test projects Sheridan County migration with four different migration rates; other parameters receive only limited explanation or support.

Exportability

Judging exportability requires (i) clearer exposition of model than in documents cited and (ii) parameter testing in other counties. Detailed employment forecasts and cohort-survival model may increase exportability while specific model characteristics may interfere with its application elsewhere.

Usefulness

Excellent analysis of several other projection studies but otherwise of limited value for policymakers; were we better able to understand the model it might appear more useful. Estimates of county-level impacts for years during the operation phase, plus combination of export and local construction activities, exclude application to many policy problems.

Procedures cannot be replicated from explanations presented; two supporting documents [40,41] explain methods further, but sill lack detail to allow replication.

[14] Maxwell, Lynn C. and Neesham, Kenneth. A Model for County Population Projections. Laramie, Wyoming: Division of Business and Economic Research, University of Wyoming, June 1973. Prepared for the Wyoming Department of Economic Planning and Development.

Design Purpose

General model for predicting county population over time in Wyoming.

Special Features

Excellent explanations of development and application of location quotients and cohort-survival models.

Tests

Parameter estimation procedures well explained and referenced and regression analyses include significance levels, but application in a boomtown situation should be preceded with further testing. Appears no worse than other models developed from a "business as usual" period.

Exportability

Not designed specifically for boomtown changes; may be inappropriate for predicting energy development impacts.

Usefulness

Replication no problem as study includes both parameters and computer program; should be excellent for projecting baseline (i.e., without energy development) employment and population. Cannot easily distinguish differences in construction and operation phases; we hesitate to recommend its use in rapid-growth settings.

[15] Polzin, Paul E. Water Use and Coal Development in Eastern Montana. Bozeman, Montana: Montana University Joint Water Resources Research Center, 59715, November 1974.

Design Purpose

Quantify socio-economic consequences of Eastern Montana coal development.

Special Features

Consideration of reduced agricultural production; cohort-survival model captures some labor force and population dynamics.

Tests

Questionable and important parameters subjected to either sensitivity or significance testing; and the two most important standards, income multipliers and labor force participation rates, appear valid.

Exportability

Robust, respects data limitations, and avoids complicated detail. Measure of agricultural impacts must be adjusted for local weather conditions or types of energy development.

Usefulness

Displays acute awareness of limitations; stresses its application to determine a rough idea of coal development impacts and not to decide important coal development questions. By predicting impacts at multi-county levels in 1980 and 1985, and by considering only county and state finances, yields only a general picture of effects. Included references and explanations permit replication elsewhere (at multi-county or state levels) by someone familiar with regression analysis and computer programming.

[16] [Anonymous]. Effect of Coal Development in the Northern Great Plains: A Review of Major Issues and Consequences of Different Rates of Development. Denver, Colorado: Northern Great Plains Resources Program 1975.

Design Purpose

Summarizes Northern Great Plains Resource Program (NGPRP) work group reports and includes some additonal predictions.

Special Features

Discusses and projects first-order effects on agriculture.

Tests

None reported.

Exportability

Projection procedures neither explained nor referenced; exportability indeterminate.

Usefulness

Includes limited explanations of parameters defining future services' operating costs, and most predictions reflect three NGPRP coal development profiles.

[17] University of Denver Research Institute. Factors Influencing an Area's Ability to Absorb A Large-Scale Commercial Coal-Processing Complex, A Case Study of the Fort Union Lignite Region. Washington, D. C.: Energy Research and Development Administration, Fossil Fuels, 1975. Available from National Technical Information Service, Report # FE-1526-2.

Design Purpose

Predict consequences of very large Coal-Oil-Gas complex for rural and relatively urban areas in the Fort Union (N. Dakota, Montana, S. Dakota) region.

Special Features

Superimposes effects of large COG complex on predicted coal-based development in both an urbanized and a rural part of the study area. Emphasizes problems of rapid development and opportunities to control them.

Tests

Models based on seven case studies of energy development; no testing reported.

Exportability

Specific equations and operation of model not provided. Parameters adjusted for study area and presumably not exportable as used.

Usefulness

Publication reviewed does not provide enough technical information to implement this model elsewhere. Extensive modification required if used in different context.

[18] Wistisen, Martin J. and Nelson, Glen T. Kaiparowits Socio-Economic Study. Provo, Utah: Center for Business and Economic Research at Brigham Young University, 1973. Prepared for Bechtel Power Corporation.

Design Purpose

Part of Bechtel Power Corporation's Environmental Impact Statement for proposed development.

Special Features

Thorough comparative analysis, used in estimating parameters, recognizes data limitations and becomes a tool for using and improving imperfect historic data. Assumptions tested with theoretical and empirical questioning, seeking any spurious relationships or conditions which might make projections inappropriate.

Tests

Examines experiences in other settings (now or in the future) and analyzes selected variables through detailed review and regression analysis search for omitted variables.

Exportability

Actual assumptions may represent only the Kaiparowits study area but procedures for reaching assumptions should be highly exportable.

Usefulness

While annual projections facilitate planning for immediate effects, size of study region (Kane and Garfield Counties, Utah, and Page, Arizona) precludes specifying effects on particular local areas. Excludes facility's impacts on current population; does not project total population, total demand on schools, etc. Cohort-survival model reflects changes in labor force participation but could under-represent the level of in-migration. Clearly explains and references projection techniques and assumptions, but cohort-survival model and regression analyses require some computer skills.

[19] Woodward-Clyde Consultants. Environmental Impact Report, North Dakota Gasification Project. Bismarck, North Dakota: ANG Coal Gasification Company, 1975.

Design Purpose

Part of Environmental Impact Statement for a coal gasification project.

Special Features

Projections of secondary employment involves an inexpensive but questionable procedure and reporting format and model structure appear to serve the client's particular interests.

Tests

Testing absent, as are references and explanations of important assumptions.

Exportability

Vagueness and deviation from parameters used in other models limit exportability. Many assumptions, reflecting either national standards or the Safeguard Project's experiences, appear questionable. Examples: defines a single family home market value as three times mobile home value; expects construction and operation workers to have the same impact on secondary employment. We recommend careful analysis and testing of this model's parameters before applying it.

Usefulness

Limited use for policy-makers since represents total financial impacts over an entire period, failing to adjust for present value and ignoring short-term financial difficulties. Projecting secondary workers ignores induced changes and lacks theoretical base. Avoids problems of construction period over-capitalization, assuming those public improvements will be just sufficient for operation period. Despite simple projection procedures, poor referencing makes replication both difficult and unattractive.

[20] [Anonymous] Coal and Uranium Development of the Powder River Basin -- An Impact Analysis. Cheyenne: Wyoming Department of Economic Planning and Development, 1974.

Design Purpose

Sponsors seek model yielding accurate results requiring simple and inexpensive updating procedures.

Special Features

Despite simplicity, addresses most policy questions with general but accurate prediction.

Tests

Claims testing unnecessary since data problems require robust and simple model yielding only "ranges of impacts"; predictions appear accurate but lack supporting evidence.

Exportability

Because of generality and simplicity, appears equally applicable to other regions and situations; incorporates few assumptions, and doesn't seem peculiar to the Powder River Basin. Users may want to determine if simplicity and generality reduce exportability to significantly different situations.

Usefulness

Annual projections for three geographic levels, development alternatives and types of employment allow policy-makers to address a substantial range of problems. Projection methods and data survey techniques explained clearly and completely; could be replicated easily. Use of aggregate employment and population multipliers questionable, but may be adequate for "quick and dirty" projections.

[21] THK Associates, Inc. Impact Analysis and Development Patterns for The Oil Shale Region: Mesa, Garfield and Rio Blanco Counties, Colorado. Denver: Colorado West Area Council of Governments and The Oil Shale Regional Planning Commission, February 1974.

Design Purpose

Provide information facilitating planning decisions which mitigate adverse impacts from oil shale development.

Special Features

Housing predictions reflect family's permanence in region.

Tests

Predicts changes for three population settlement patterns; other tests not reported.

Exportability

Coefficients reflect U.S. average service levels; determining exportability requires more references.

Usefulness

Provides overview of total impacts but hinders application to local policy questions; poor referencing precludes replication; national adequacy standards do not reflect community preferences.

[22] Carlson, John F.; Doll, G. Fred; Phillips, Clynn; Lofgren, Joyce; and Brock, James W. The North Platte River Basin Economic Simulation Model, A Technical Report and Supplement. Laramie: Water Resources Research Institute, University of Wyoming, 1976.

Design Purpose

Predict behavior of economy of eight-county region in Wyoming undergoing energy development.

Special Features

Simulation model adapted from TVA-Battelle Regional Economic Simulation Model. Little treatment of government sector.

Tests

Parameters established by regression analysis of region-specific historical data. No significance tests.

Exportability

Most parameters must be established for region where applied. Not appropriate for very small region.

Usefulness

Inferences about government activity, service demand, and revenues must be derived from model's description of private sector behavior and population. Model simulates neither government sector changes (except as total government employment) nor effect of public service shortfalls on economy.

[23] Research and Planning Consultants. Offshore Oil: Its Impact on Texas Communities. Austin, Texas: Texas General Land Office, February 1977.

Design Purpose

Predict effects of outer continental shelf (OCS) oil and gas development on Texas communities.

Special Features

Three independent development scenarios postulated. Combines input-output and multiplier models for impact prediction. Includes environmental and social impact predictions.

Tests

None.

Exportability

Depends on a modified version of the Texas Input/Output Model. Applicable in large (multistate) regions if I/O model is available but probably not useful for a single state application and would in any case require extensive "customizing." Much of this study is specific to offshore oil exploration.

Usefulness

Useful to communities included in application area and to state government. Little detail in predictions, except in primary development requirements. Extensive environmental and social impact discussion.

[24] Baldwin, Thomas E.; Dixon-Davis, Diana; Stenehjem, Erik J.; and Wolsko, Thomas D. A Socioeconomic Assessment of Energy Development in a Small Rural County: Coal Gasification in Mercer County, North Dakota, Volume I. Argonne, Illinois: Argonne National Laboratory, August 1976.

Design Purpose

Develop understanding of local impacts from large scale energy development; facilitate analysis of alternative policy responses to problems.

Special Features

Predicting service demand reflects indivisibility of certain public services and nature of public consumption. Attitudinal survey used to define service needs and develop appropriate adequacy standards. Precursor to [25, 26, 27].

Tests

None reported.

Exportability

Analytical framework appears exportable; results of attitudinal survey particular to locality.

Usefulness

Not replicable from this document; Volume II, "Methodology", might permit replication.

[25] Baldwin, Thomas E.; Dixon-Davis, Diana; Metzger, James E; and Stenehjem, Erik J. A Framework for Detailed Site-Specific Studies of Local Socioeconomic Impacts from Energy Development. Energy and Environmental Systems Division. Argonne, Illinois: Argonne National Laboratory, December 1976.

Design Purpose

Provide methodology for assessing site-specific impacts of energy development and mitigation strategies.

Special Features

Employment multiplier developed using central place theory and economic base theory (recommended by [34]). Consider local unemployment, commuting preferences, and locally available labor force when predicting inmigrant employees. Population settlement patterns function of housing preferences, commuting distances, community services, income, and housing availability. Attitudinal survey permits prediction of change in definition of public service needs and adequacy.

Tests

None reported.

Exportability

Model appears highly exportable; assessment analysis would probably differ among regions and communities.

Usefulness

Incorporates local attitudes defining public service adequacy, which precludes errors involved with national and regional adequacy standards. Explanations too brief to permit detailed replication. Produces accurate data sufficient for many policy decisions.

[26] Stenehjem, Erik J.; Baldwin, Thomas E.; Metzger, James E.; and Dixon-Davis Diana. A Framework for Comparative Analysis of Socioeconomic Impact: Case-I. Argonne, Illinois: Argonne National Laboratory, December 1976.

Design Purpose

Permit easy evaluation of local socioeconomic changes caused by energy development.

Special Features

Allocates county population to localities through econometric spatial model -- maximizes commuting, housing preferences; controls for income and housing availability. Less sophisticated gravity model included. Projects public service requirements from service specific multipliers; vary by type and size of community. Three computerized modules permit extensive user interaction. Application of [27].

Tests

None reported.

Exportability

Multipliers, employment and public services coefficients designed to permit exportability; user should carefully assess their derivation (not available here) to determine actual exportability.

Usefulness

Given reliable multipliers, methodology reflects actual inmigrant decision-making process without reducing flexibility or accuracy. Replication requires further documentation; explanations sufficient to determine value to particular decision-makers.

[27a] Stenehjem, Erik J. and Metzger, James E. A Framework for Projecting Employment and Population Changes Accompanying Energy Development: Phase I. Argonne, Illinois: Argonne National Laboratory, August 1976.

[27b] ______________. Phase II. October 1976.

Design Purpose

Provide government officials with procedures for predicting local economic and population changes (Phase I) and impacts on local public services and facilities (Phase II) resulting from a variety of proposed energy developments.

Special Features

Presents data for predicting basic employment for eight types of energy development. Time-lag model adjusts employment multipliers. Explains and specifies several spatial allocation models; develops public service standards reflecting demographic and other special conditions. Stresses accuracy rather than precision through presentation of methods; demonstrates them through step-by-step explanation of their application.

Tests

No tests reported; compares results from various prediction methods explained in the document.

Exportability

Disaggregated derivation of employment multipliers and service standards; documents various methods for predicting the same data and discusses their appropriateness under different conditions. Exportability major objective of model.

Usefulness

Written in layman's language, covering strengths, weaknesses, and appropriateness of each methodology. Includes coefficients for predicting changes. Examples of methodology application demonstrate calculation process; model application requires little technical training.

[28] Freudenthal, David D.; Ricciardelli, Peter; York, Michael N. Coal Development Alternatives; An Assessment of Water Use and Economic Implications. Cheyenne: Wyoming Department of Economic Planning and Development, 1974.

Design Purpose

Compare consequences of alternative means of exploiting Wyoming coal, especially with regard to water demand.

Special Features

Differs substantially from typical predictive models: describes employment, assessed valuation, population and coal use (or water demand) for unit quantities of water consumption (or coal production) for several different coal conversion options. Oriented to comparison of opportunity costs of state energy policy alternatives: e.g., "How many more jobs would be provided if 10,000 acre-feet of water were devoted to coal conversion option A rather than B."

Tests

None reported.

Exportability

Applicable to similar policy decisions in other semi-arid states or regions.

Usefulness

Informative and well-suited to its purpose but not a predictive model easily used by a community facing a specific development alternative, except for rough estimation of a few variables.

[29] [Anonymous]. The Anticipated Impact of Colstrip Generators #3 and #4 on Public Services, Housing and Commercial Services in Colstrip, Forsyth. Bozeman: Center for Interdisciplinary Studies, Montana State University, July 1974.

Design Purpose

Predictions of effect of generating plant construction for state and local government planning.

Special Features

Highly discursive; little analytic methodology.

Tests

None.

Exportability

Projections are based on interviews and "soft" data. Special regional characteristics not likely to be similar in new applications limit exportability; methodology not explicitly presented.

Usefulness

Detailed discussion of several sectors of local public and private economy, but no discussion of fiscal effects. Provides better insight into the nature of rapid development problems than into their dimensions.

[30] Leholm, Arlen G.; Dalsted, Norman L.; Toman, Norman E.; Leistritz, F. Larry; Hertsgaard, Thor A.; Coon, Randal C. Economic Impacts of Construction and Operation of Coyote Station #1 Electrical Generation Plant and Expansion of Coal Handling Facilities at the Beulah Mine of Knife River Coal Company. Prepared for Sterns-Roger, Inc., Denver. Fargo, North Dakota: Department of Agricultural Economics, North Dakota State University, May 1976.

Design Purpose

Predict social and economic consequences, especially for state and local government, of a 440 MW power generating station in Mercer County, North Dakota.

Special Features

Extenstive baseline data presented. Highly disaggregated treatment of public services.

Tests

None reported.

Exportability

Depends on good baseline projections for new application, and state input/output coefficients for new application. Requires detailed but practicable modification for a new application.

Usefulness

Inconvenient for comparison of alternative policies. Very detailed projections for specific sources of revenue and public expenditure.

[31] Schuller, C. Richard and Hiltunen, Ronald A. A Generalized Public Budget Analysis. ONRL/RUS-22. Oak Ridge, Tennessee: Oak Ridge National Laboratory, Regional Environmental Systems Analysis Program, September 1976.

Design Purpose

Create working model predicting local fiscal impacts of a development or a management strategy.

Special Features

Develops coefficients from 15 years historical data. Builds on output from ORNL/RUS-25. Defines per capita property taxes as a function of total personal income and per capita sales tax revenue as a function of median family income, percent urban population, and county "recreation potential." Service expenditures estimated from historical county per capita expenditures; general expenditures are a function of total personal income and service growth factor.

Tests

Tests some estimated coefficients for fit with historical county data; sensitivity tests not reported.

Exportability

Formulae for calculating transfer payments specific to region, but basic concepts appear exportable. Methods for estimating coefficients depend on correlations, not causal relationships, which may not hold true elsewhere.

Usefulness

Dependence on historical data may reduce usefulness in energy development localities. Given population and income forecasts and coefficients, projection methods easily replicated by those with minimal computer skills. Some calculations of input data confusing, but overall methodology simple.

[32] Bickert, Browne, Coddington and Associates Inc. "Estimates of Public Sector Financial Needs, Six Western Colorado Communities." Volume II of Boom Town Financing Study. Denver: The Boom Town Financing Study, Colorado Department of Local Affairs, Office of Rural Development, July 1976.

Design Purpose

Estimate economic and fiscal impacts of fossil fuel development on six Colorado Communities.

Special Features

Predicts public finance impacts for peak years only. Compares coefficients and results with other projections for same counties.

Tests

Implied testing involves comparison with other projections.

Exportability

Methodology simple and exportable but coefficients peculiar to localities and to specific types of facilities and developments. Dependence on adjusted historical per capita data reduces exportability.

Usefulness

General methodology is explicit, but particular estimation assumptions are not specific enough for replication. Consideration of only peak years limits policy-making usefulness to very aggregate decisions and precludes overall understanding of the developments' impacts.

[33] Ryan, J. J. and Welles, J. G. Regional Economic Impacts of a U.S. Oil Shale Industry, No. 1; Public Policy Studies of a U. S. Oil Shale Industry. Denver: Denver Research Institute, University of Denver, 1966.

Design Purpose

Indicate regional second-order impacts from oil shale development in Colorado.

Special Features

Employment multipliers adjust over time; assume increasing productivity among operation workers; predict impacts for four levels of industry development.

Tests

None reported.

Exportability

Standards reflect recommended service levels, applicable for Colorado communities; exportability of other coefficients questionable.

Usefulness

Provide overview of possible regional impacts of energy development; some assumptions appear dated; sources of assumptions not explicit.

Additional Studies

Additional studies excluded from this critique are listed below for the reader's convienience. Either these were received too late to analyze or detailed methodology sections have not yet been received. For several, methodology volumes are in press.

[47] Leistritz F. Larry and Murdock, Steven H. Research Methodology Applicable to Community Adjustments to Public Land Use Alternatives. Fargo, North Dakota: Department of Agricultural Economics, Department of Sociology, North Dakota State University, March 1977.

Describes most recent version of REAP's Economic-Demographic model and application to local land-use problems. Displays much improvement over earlier versions reviewed here [5, 11, 11a, 30]. Two REAP documents supply even more thorough explanations:

[48] Hertsgaard, Thor A.; Murdock, Steven H.; Henry, Mark; and Ludtke, Richard. The REAP Economic-Demographic Model: Technical Description. Bismarck: North Dakota Regional Environmental Assessment Program, 1977.

[49] North Dakota Regional Environmental Assessment Program. The REAP Economic Demographic Model 1: User Manual. Bismarck: North Dakota REAP, State Capitol, December 1976.

REAP, funded mostly from state appropriations, uses model to provide "client" localities with predictions of changes expected from extensive energy development.

[50] Resource Planning Associates, Inc. Identification and Analysis of Mid-Atlantic Onshore OCS Impacts. Dover, Delaware: Middle Atlantic Governor's Coastal Resources Council, Delaware State Planning Office, 1976.

Compares assumptions, methodology, and predictions of six models forecasting onshore impacts from mid-Atlantic Outer Continental Shelf (OCS) developments.

[51] Copley International Corporation. Health Impacts of Environmental Pollution in Energy Development Impacted Communities: Vol. I and II. Denver: Office of Energy Activities, Environmental Protection Agency, Region VIII, September 1976.

Procedures and methodology volume to be released presently.

[52] New England River Basin Commission. Onshore Facilities Related to Offshore Oil and Gas Development. Vol. I: "Factbook"; Vol. II: "Estimates for New England." Boston, Massachusetts, April 1977.

Volume III, "Methodology," presently being reviewed and approved for circulation.

[53] Stenehjem, Erik J.; Hoover, L. John; Krohm, Gregory C. On Analysis of the Sensitivities of Local Socioeconomic Impacts to Variations in the Types and Rates of Coal Development and Differences in Local Site Characteristics. Argonne, Illinois: Energy and Environmental Systems Division, Argonne National Laboratory, February 1977.

[54] Denver Research Institute. Analysis of Financing Problems in Coal and Oil Shale Boom Towns. Washington, D. C.: Environmental Policy Office, Federal Energy Administration, July 1976. National Technical Information System Report No. FEA/D-76/361.

[55] Bureau of Reclamation, Department of the Interior. Final Environmental Statement, Proposed Western Gasification Company (WESCO), Coal Gasification Project, and Expansion of Navajo Mine by Utah International Inc., San Juan County, New Mexico. Salt Lake City: Upper Colorado Regional Office, 1976.

Figure 4: Descriptive Summary of Projection Studies: Inputs, Outputs and Processes

Projection Studies Reviewed[1]

Summary Characteristics	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33
Input variables — Data the user must supply																																	
• Basic Employment	●	●	●			●	●	●				●		●			●	●		●	●	●		●	●	●				●		●	●
• Population				●					●															●		●	●		●		●		
• Energy Production																																	
output or capital investment								●	●				●										●	●			●	●				●	
expenditures					●					●	●																			●			
• Income	●		●			●															●										●		●
Output Variables — Types of impacts predicted																																	
• Basic Employment			●		●			●			●		●		●	●							●	●			●	●					
• Secondary Employment										●		●				●						●						●					
Single category		●															●	●		●			●	●	●							●	●
Multiple categories[3]	●		●		●	●		●		●	●		●	●	●				●		●	●				●	●			●			
• Population										●							●											●					
Single category		●			●		●	●				●	●			●			●		●		●	●			●					●	
Multiple categories	●		●			●								●				●		●		●			●	●				●			●
• Housing	●	●				●	●	●			●	●			●	●	●	●	●		●	●	●		●				●			●	
• Personal Income																								●									
Single category		●					●	●			●	●						●	●				●							●			
Multiple categories	●		●			●				●					●		●				●	●											
• Retail Services																						●							●				
Sales Volume		●			●	●	●	●				●			●		●	●	●												●	●	
Space Requirements	●					●		●				●					●	●															
• Public Services																									●								
Not Distinguished by Type			●					●															●										
Education																						●											
Grade Levels Distinguished	●	●		●					●	●	●	●			●		●	●			●			●			●			●			●
Grade Levels Not Distinguished							●									●			●				●						●				
Capital/Operation Impacts Distinguished		●		●			●		●	●	●	●			●	●		●			●						●			●			●
Capital/Operation Impacts Not Disting.																	●		●				●	●					●				
Water and Sewerage																												4					●
Capital/Operation Impacts Distinguished	●	●		●			●		●		●	●							●		●												
Capital/Operation Impacts Not Disting.																	●	●					●							●			
Roads and Highways																																	
Capital/Operation Impacts Distinguished	●	●		●					●		●	●				●			●		●			●									●
Capital/Operation Impacts Not Disting.																													●	●			
Other Public Services																																	
Capital/Operation Impacts Distinguished	●	●		●			●		●		●	●					●		●		●					●	●			●			
Capital/Operation Impacts Not Disting.										●							●	●						●					●				●
• Public Expenditures																									●								
Single category			●	●	●			●															●										
Multiple categories	●	●					●		●	●	●	●			●	●	●	●			●			●						●	●	●	
Capital/Operation Impacts Distinguished[2]	●	●	●	●			●	●	●	●	●	●			●	●			●		●			●						●	●	●	
Capital/Operation Impacts Not Disting.																	●	●					●										
• Public Revenue																									●								
General Revenue (Source Not Distinguished)			●													●						●	●										
Property Tax	●	●		●			●	●	●	●	●	●			●		●	●	●		●			●					●	●	●	●	●
Sales Tax		●		●			●				●	●					●		●		●			●							●	●	
Income Tax				●						●	●	●			●		●	●	●											●			
Royalties and Severance Tax				●						●					●	●	●	●												●			
Transfer Payments		●						●	●	●		●									●			●						●	●		
Other		●		●					●												●			●						●	●	●	
Public Revenue / Expenditure Comparison		●	●	●				●	●	●		●					●				●		●	●	●						●	●	
Geographic Limits of Analysis																																	
• Municipal	●	●	●			●		●	●	●		●				●			●	●				●		●	●					●	
• School District	●	●							●															●								●	
• County	●	●		●					●	●	●	●	●	●		●				●				●		●	●			●	●	●	
• Multi-County Region					●		●			●			●		●	●	●	●	●	●	●	●	●						●	●		●	
• State										●	●				●								●					●					
Development Stages																																	
• Consider Only Operation Stage Impacts					●																												
• Distinguish Construction /Operation Stage Impacts		●	●	●		●	●	●			●	●			●	●	●	●	●	●		●	●				●		●	●		●	●
• Combine Construction / Operation Stage Impacts	●								●					●		●					●			●	●	●					●		
Time Characteristics — Frequency of Projected Output																																	
• Annual	●		●			●	●	●	●	●	●	●		●			●	●	●	●		●		●	●	●	●	●		●		●	
• Quinquennial	●				●				●				●			●				●											●		
• Decennial																																	
• One Year (or average year)		●					●					●						●	●		●									●		●	
• Other				●											●								5						●				
Mathematical Models — Types Used for Projections																																	
• Gravity	●	●				●													●	●						●	●					●	
• Cohort-Survival													●	●				●							●	●	●			●			
• Input/Output					●						●												●							●			
• Simulation	●		●			●		●		●			●									●			●		●						
• Coefficients	●	●		●	●				●		●		●		●	●		●	●	●	●		●	●	●	●	●	●			●	●	●
• Export-Base Multipliers	●	●					●					●	●	●	●		●	●		●	●		●	●	●	●	●	●				●	●
• Adequacy Standards				●				●	●			●					●	●			●					●	●		●				

[1] Numbers correspond to references in text - see Part IV.

[2] A few models distinguish capital/operation impacts without predicting both types of impacts

[3] Multiple categories not including separate consideration for construction and operating impacts.

[4] Water used per year

[5] Irregular 2-5 month periods, 6-year span

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